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MANUFACTURING INDUSTRY IN BELFAST, NORTHERN IRELAND

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BELFAST, the capital of Northern Ireland, dominates all other urban centers in the province. In 1951 the city had a population of 443,680, which represents about one-third of the total population of Northern Ireland. Londonderry city, with a population of only 50,095, was next in size.[1]

BELFAST THE MAJOR CENTER OF MANUFACTURING IN NORTHERN IRELAND

One of the most striking features of the distribution of industry in Northern Ireland is the marked concentration of manufacturing in Belfast. In 1951 approximately 58 percent of the total persons engaged in manufacturing in Northern Ireland were employed in factories located in the Belfast Employment Exchange area.[2] Outside the city, industries were usually only of local importance although Londonderry shirt factories were an exception, for they provided employment for almost a quarter of the total engaged in clothing in Northern Ireland. In 13 of the 14 major industrial groups in manufacturing industry (as classified in the Standard Industrial Classification List[3]), Belfast had the greatest concentration. The exception, leather, was a very minor industry. Table 1 gives a further measure of the extremely high degree of concentration of manufacturing industries in the Belfast Employment Exchange area in 1951.

Belfast is primarily an industrial city, for in 1951 manufacturing provided employment for 50 percent of all persons working there. In Northern Ireland as a whole, however, specialization in manufacturing was not so great, for only 36 percent of the total working population was engaged in manufacturing.

Industry in the city may be conveniently classified into five industrial groups

[1] Government of Northern Ireland, *Ulster Year Book, 1953* (Belfast, 1953), p. 31.

[2] The Belfast Employment Exchange area is that served by the local office of the Ministry of Labour and National Insurance. It is somewhat larger in area than the County Borough of Belfast (Fig. 1). Northern Ireland is served by 27 similar local offices, but the areas they serve vary considerably in size.

[3] Central Statistical Office, *Standard Industrial Classification* (London: His Majesty's Stationery Office, 1951).

in the following order of importance (1) engineering and vehicles, (2) textiles, (3) clothing, (4) food, drink, and tobacco, and (5) miscellaneous industries. Table 2 shows that there is a considerable degree of specialization in the structure of industry in Belfast, and this is also true of manufacturing in Northern Ireland as a whole. In addition, the table indicates the dominant position of engineering in Belfast in contrast to the supremacy of textiles in the province as a whole. However, engineering only attained its leading position in the city during the second

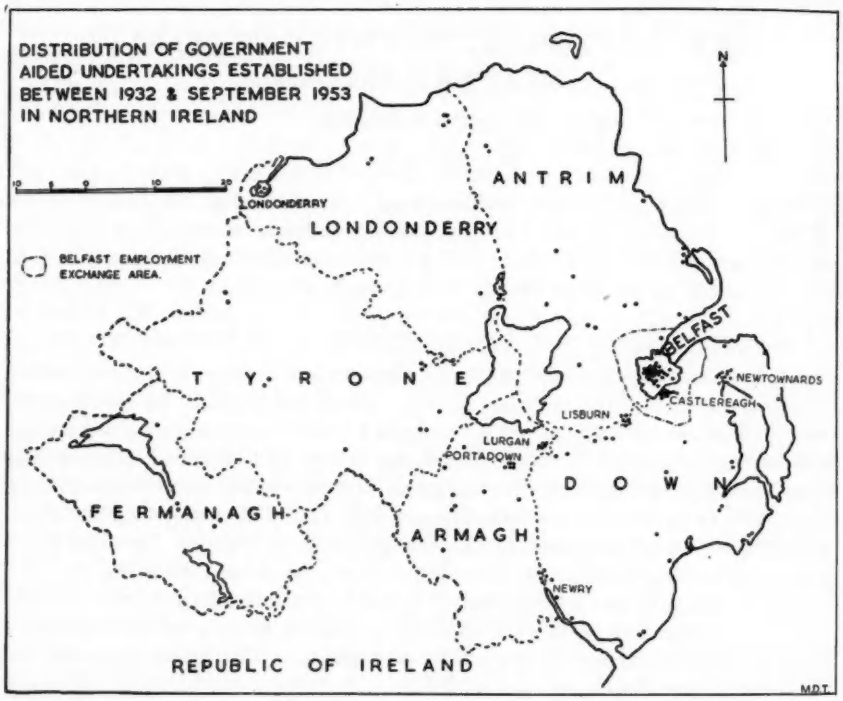

FIG. 1.

world war. Textiles lost the premier position which they had held in Belfast for many centuries, chiefly as a result of a gradual decline in the importance of linen products in the city. On the other hand, the demand for various engineering and vehicle products increased in recent years, especially during World War II, and old and newly established firms expanded production to satisfy this growing demand. Consequently, the number of persons employed in engineering and vehicle industries more than doubled between 1935 and 1951.

Most of the factories in Belfast are situated within a mile and a quarter of the city hall, which is the city's focal point (Fig. 2). Practically all the clothing, tex-

tile making-up, soft drink, tobacco, printing and food processing establishments are located within three-fourths of a mile from the city center. The flax spinning and linen weaving factories are mainly concentrated in west Belfast along the rivers Forth, Farset, and Blackstaff. A number of spinning mills are situated in the upper reaches of these streams, having been established there when the mills were dependent on water power. In east Belfast, along the river Connswater, there is a minor concentration of textile establishments dominated by a large rope works,

TABLE 1

A MEASURE OF THE CONCENTRATION OF MANUFACTURING INDUSTRIES IN THE BELFAST EMPLOYMENT EXCHANGE AREA IN 1951*

Industry	Percent of total in Belfast	Percent of total in manufacturing in Northern Ireland
Linen industry		
Spinning	59.9	13.7
Weaving	39.4	10.8
Other textiles	39.0	11.5
Total textiles	48.5	36.0
Shipbuilding	99.0	8.2
Marine engineering	100.0	3.6
Vehicles	65.5	6.6
Other engineering	87.0	6.6
Total engineering	82.5	25.0
Clothing	45.5	17.0
Food, drink & tobacco	56.5	11.4
Manufactures of wood & cork	53.8	3.0
Paper & printing	70.0	2.7
Non-metalliferous mining products	36.2	2.0
Metal goods	40.5	1.1
Remaining industries	53.0	1.8
Total percent	58.0	100.0
Total number of persons employed	125,000	215,000

* The labor criterion is used and employers and employees were considered. Statistics relating to employment in industry in 1951 were obtained from a 25 percent sample, taken by the author, of employment returns from all industrial establishments in Northern Ireland. The writer is grateful to the statistical officer, Mr. Park, of the Ministry of Labour and National Insurance, Northern Ireland, for permission to make the survey, and for his help and guidance. Other statistics used in this paper unless otherwise stated were obtained through field work.

the largest of its kind in the world. All shipbuilding and marine engineering, as well as most mechanical and electrical engineering and aircraft production, are carried on in east Belfast along the right bank of the river Lagan and near its mouth. West Belfast, however, where the Farset River turns east (Fig. 2), has a minor concentration of engineering and vehicle production. The largest mechanical engineering factory in Belfast, employing some 5,000 persons, is situated in this area.

Since 1945 an important concentration of manufacturing has grown up on the southeast boundary of Belfast on an industrial estate owned by the government of

Northern Ireland. A similar industrial estate is now being developed near the northern boundary of the city. Production is quite varied in the government-built factories on these estates. Precision engineering, rayon spinning, food processing, toy making, and the manufacture of aircraft parts are some of the activities carried on in these factories.

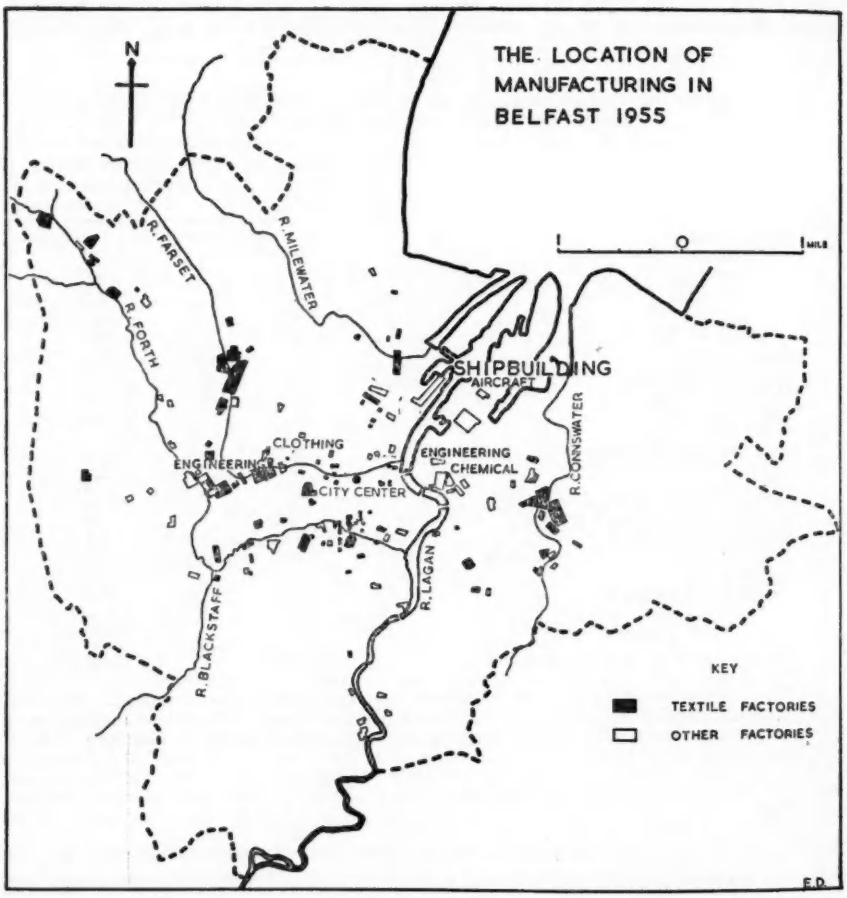

FIG. 2.

Approximately 80 percent of the 125,000 workers engaged in manufacturing in Belfast live in the city itself. The remainder travel daily from an area within 20 miles of the factories in which they work. In contrast to American workers, very few workers in Belfast factories commute by automobile. Public buses provide

the chief means of transport and usually only directors and management staff can afford to use automobiles. A large number of employees live within convenient walking distance of their place of employment, while many ride to and from work on bicycles.

The brief description above of manufacturing in contemporary Belfast contains many aspects that are worthy of elaboration and further study. This paper, however, will be confined to a brief analysis of how Belfast became the dominant center of industry in Northern Ireland, and how the city came to have its present industrial structure. In addition, current attempts to disperse industry more evenly

TABLE 2

THE STRUCTURE OF MANUFACTURING INDUSTRY IN BELFAST IN 1951

Industry	Percent of total working in manufacturing industry	
	Belfast	Northern Ireland
Linen industry		
Spinning	13.8	13.7
Weaving	7.4	10.8
Other textiles	7.9	11.5
Total textiles	29.2	36.0
Shipbuilding	13.4	8.2
Marine engineering	6.5	3.6
Vehicles	7.8	6.6
Other engineering	10.3	6.6
Total engineering	38.0	25.0
Clothing	13.0	17.0
Food, drink & tobacco	11.0	11.4
Manufactures of wood & cork	2.6	3.0
Paper & printing	3.2	2.7
Non-metalliferous mining products	1.2	2.0
Metal goods	.8	1.1
Remaining industries	1.0	1.8
Total percent	100.0	100.0
Total number of persons employed	125,000	215,000

throughout Northern Ireland and to diversify the industrial structure will be examined in an attempt to measure the success of such official policies and their effects on manufacturing in Belfast.

BELFAST AS A LOCATION FOR INDUSTRY

To understand the growth of Belfast as the dominant center of manufacturing in Northern Ireland, a brief examination of the location and site of the city is required. Belfast stands at the head of a long inlet of the Irish sea midway down the east coast of Northern Ireland. The city nestles in a broad amphitheatre of hills (Fig. 3). To the north and northwest stand the black, basalt-capped sentinels—Cave Hill and Divis, respectively 1188 and 1567 feet in height. These mountains

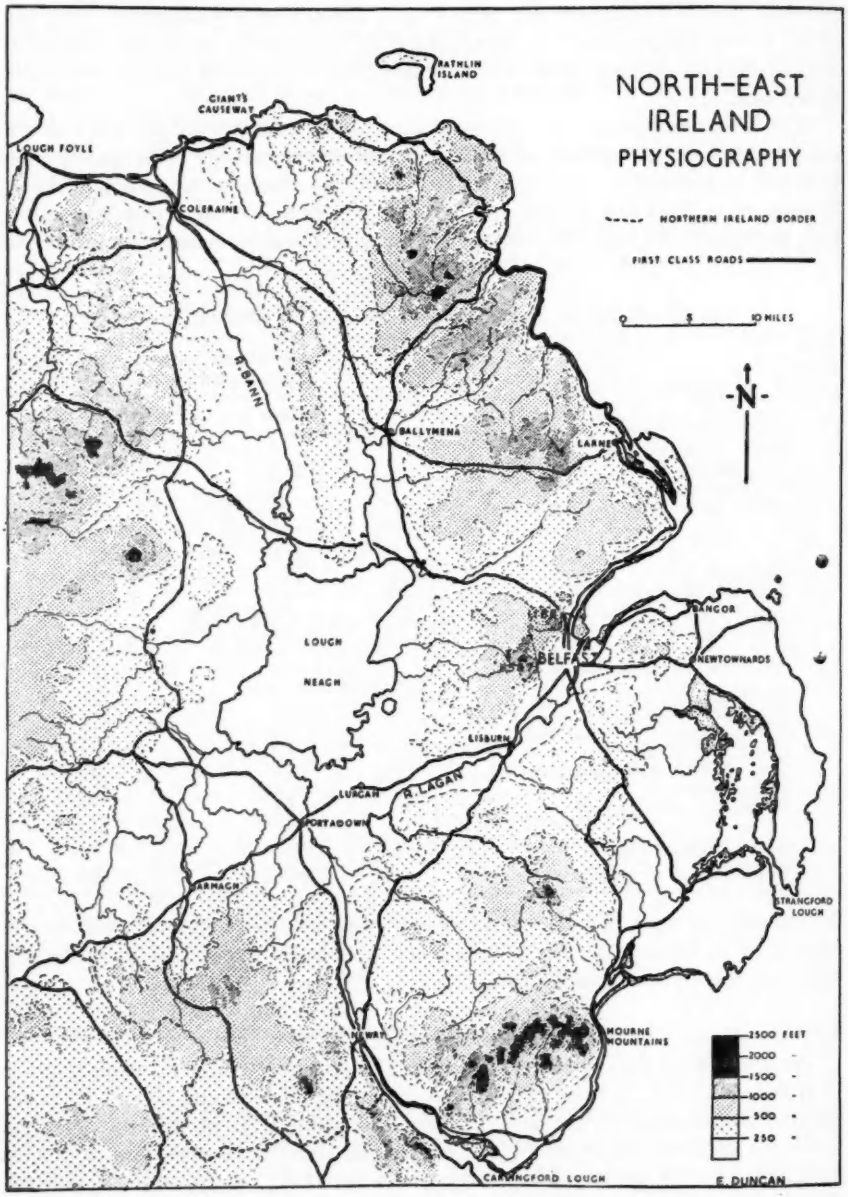
NORTH-EAST
IRELAND
PHYSIOGRAPHY
NORTHERN IRELAND BORDER
FIRST CLASS ROADS
0 5 10 MILES
N
RATHLIN ISLAND
GIANT'S CAUSEWAY
LOUGH FOYLE
COLERAINE
R. BANN
BALLYMENA
LARNE
LOUGH NEAGH
BELFAST
BANGOR
NEWTOWNARDS
LISBURN
LURGAN
R. LAGAN
PORTADOWN
ARMAGH
STRANGFORD LOUGH
NEWRY
MOURNE MOUNTAINS
2500 FEET
2000
1500
1000
500
250
CARLINGFORD LOUGH
E. DUNCAN

FIG. 3.

form part of the steep, southern rampart of the Antrim Plateau. Belfast itself is mainly situated on the low-lying estuarine clays which overlie Triassic beds. To the east and south of the city the land rises fairly quickly to the well cultivated Ordovician slopes of the Hollywood and Castlereagh hills which in a few places exceed 500 feet in height. The river Lagan which flows into Belfast Lough at Belfast provides a fine routeway southwestward into the heart of the province, while numerous passes in the surrounding uplands have also facilitated the growth of a fine communications network radiating from the city to all parts of the province.

The natural advantages of Belfast's location and site were not utilized to any great degree in the 18th century. With a population of approximately 12,000[4] around 1780 Belfast was comparable in size to Newry and Londonderry, which also combined marketing and port functions. Market towns, such as Lisburn, Portadown, and Ballymena, were not much smaller in size. The urban pattern in the mid-eighteenth century held little promise of the great disparity between contemporary Belfast and the other cities and towns in the province. Without doubt, the physical factors influencing the location and site of Belfast were favorable, thus providing the city with great potential for expansion. But these factors do not by themselves explain the present size of Belfast or its dominant position of being by far the main center of manufacturing in Northern Ireland. What were the factors then which made it possible for the natural advantages of the city to be exploited more fully?

A search for causal factors would reveal that in the late 18th century there was a considerable acceleration in economic activity. Industry and agriculture in the province as a whole showed a significant expansion and departure from a subsistence basis. Associated with such development there was a significant increase in the population.[5] The production of a surplus of manufactured goods and farm products and their shipment (mainly to Britain) greatly contributed to the growth and importance of Belfast because of the city's suitable docking facilities and its proximity to the British market. In addition, the end of the 18th and beginning of the 19th century witnessed the rapid growth of a fine road network in the province,[6] mainly as a result of the economic developments then taking place. The new and greatly enlarged network of roads was focussed on Belfast, thus enlarging the city's hinterland and contributing to its growth and importance as a node and port.

Around 1780 Belfast was not a particularly important center of manufacturing. In fact, towns such as Lisburn, Lurgan, Portadown, and Dungannon were as important centers of manufacturing as Belfast. No one town was in a dominant position, nor was manufacturing in a really thriving condition anywhere in the

[4] E. R. R. Green, "Economic History," *Belfast in Its Regional Setting,* prepared for the meeting of the British Association for the Advancement of Science, 1952 (Belfast, 1952), p .124.

[5] K. H. Connell, "Some Unsettled Problems in English and Irish Population History, 1750–1845," *Irish Historical Studies,* Vol. VII, No. 28 (Sept. 1951).

[6] I. J. Herring, "Ulster Roads on the Eve of the Railway Age, 1800–40" in *Irish Historical Studies,* Vol. 2 (1940–41), and M. D. Thomas, "Communications in Mid-Ulster," *Ulster Journal of Archaeology,* 1951, pp. 119–128.

province. For several centuries before 1780 the growth of manufacturing in Belfast, as elsewhere in Ireland, was fettered by economic and political controls imposed by England on the Irish economy.[7] Linen was the only relatively important industry which had a surplus for export. There were a few other small industries but these catered only to local demand. Following a marked relaxation in some controls in 1779 and 1780, conditions were much better for industrial development. Population and wealth in the United Kingdom and the United States were also increasing in this period, thus creating a growing demand for manufactured goods. Under these stimuli, manufacturing in Northern Ireland in general and Belfast in particular made significant progress.

In Great Britain manufacturing was at a far higher commercial and technological level than in Northern Ireland, and Britain also had a far greater range of nationally produced raw materials. In general, therefore, industry in Northern Ireland could not compete on equal terms with British industry.

Northern Ireland is poorly endowed with raw materials. This shortage has always in the past restricted the range of industries which could be developed without being subjected to severe competition from similar industries in Great Britain. When restrictions on trade were eased in 1780 there was a marked increase in linen production, which was already localized in northeast Ireland. Development was concentrated in the linen industry which was the most competitive. At that time the linen industry was primarily based on locally grown flax and as the industry was still a domestic one, fuel requirements were negligible. Only bleach-works needed considerable supplies of fuel, and initially they used local peat.[8] Competition from the English and Scottish linen industries was not acute because the demand for linen was growing. In general, competition is less between similar firms and industries when demand is high. In other words, the intensity of competition is often a function of the level of demand. Linen production in the late 18th century could not be mechanized because the fiber lacked elasticity, and the industry consequently employed a proportionately large number of workers. The British linen industry had therefore to face severe competition for capital and labor from other rapidly developing industries which were relatively more remunerative to the factors of production. Northern Ireland, on the other hand, had a plentiful supply of labor which was cheap but highly skilled.

Capital was scarce, but as the linen industry in Northern Ireland was still organized on a domestic basis this factor had little influence over the actual production of yarn and cloth, although it was extremely important in the finishing and sales branches of the industry. The linen industry in the province was therefore able to take advantage of the more favorable economic conditions which existed after 1780 because the demand for linen was increasing and the industry was in a good

[7] M. D. Thomas, *The Economic Geography of Manufacturing Industry in Northern Ireland.* An unpublished Ph.D. thesis in geography. Queen's University, Belfast, Northern Ireland, May 1954.

[8] A bleaching establishment handling 5,000 webs a year used 110,000 cubic yards of peat. See J. McEvoy, *Statistical Survey of County Tyrone* (Dublin, 1802), p. 137.

competitive position. It was on this foundation that Northern Ireland's modern manufacturing industry was built.

Linen production in Belfast increased rapidly as it did in many other towns in Northern Ireland after 1780. In contrast to the rest of Northern Ireland the industrial base of Belfast had changed from linen to cotton production by the close of the 18th century.[9] The cotton industry by 1800 had established the town as the leading center of manufacturing in the province.

The cotton industry was first established in Belfast in 1777. The man who introduced the industry was a prominent citizen who was greatly interested in improving conditions in the town. But the cotton industry made little progress until the 1890's. Then in 1894 a high tariff provided more than adequate protection for the infant industry[10] and under the stimulus of a growing home[11] demand it developed rapidly. Belfast proved to be a good location because as a port town it had ready access to imported raw materials, and the fine growing road network

TABLE 3

WEEKLY WAGES IN THE LINEN AND COTTON INDUSTRIES 1800–1811*

Cotton			
Spinning		*Weaving*	
Female	70¢–$2.24	Fustian	$1.26–$2.10
Male	$5.60	Calico	$1.68–$2.10
		Muslin	$2.52–$2.94
Linen			
Females		*Males*	
Coarse	21–42¢	Coarse	84¢–$1.05
Fine	84¢	Fine	$1.40

* Rate of exchange used is 2.80 dollars = 20 shillings. Source of data: Dubourdieu, *Statistical Survey of County Antrim* (Dublin, 1812), pp. 394, 411; *Ibid, Statistical Survey of Down* (Dublin, 1802), p. 223; and H. McCall, *Ireland and Her Staple Manufactures* (Belfast, 1870), p. 499.

centered on the town facilitated the distribution of the finished goods to various parts of the province. Belfast also had a plentiful supply of adaptable workers traditionally skilled in textiles.

By 1800 the formerly important linen industry was practically eliminated from the town, and in 1811 the highly capitalized cotton industry was providing employment for 52,000 persons in the area within ten miles of Belfast. Most of the workers were employed in the town itself.[12] Without doubt one of the main reasons the linen industry was driven out of Belfast in this period was that the cotton industry offered better wages, as shown in Table 3.

[9] J. J. Monaghan, "The Rise and Fall of the Belfast Cotton Industry," *Irish Historical Studies*, Vol. X, No. 31 (March, 1952).

[10] A. E. Murray, *Commercial Relations between England and Ireland* (London, 1903), p. 281.

[11] "Home" in this context means mainly Belfast and Northern Ireland and to a much lesser extent the rest of Ireland.

[12] Dubourdieu, *Statistical Survey of County Antrim* (Dublin, 1812), p. 318.

Even at the beginning of the 19th century Belfast's industrial structure was specialized.[13] Cotton was the only large industry in the city. Although the important present-day shipbuilding and engineering industries had already been established in the 1790's, they remained of little significance until later in the 19th century. The minor industries located in Belfast at the beginning of the last century also included brewing, distilling, milling and glass, pottery, leather, soap and candle-making industries.[14] All the industries in Belfast were mainly dependent on the Northern Ireland or local markets and, with the exception of the cotton industry, relied chiefly on the province for sources of raw materials.

By 1827 all protective duties were removed from imports into Northern Ireland and the chief sufferer was the cotton industry. Many minor industries in Belfast, such as those making glass, leather, pottery, soap and candles, also declined because of the removal of protective duties and as a result of increased competition from similar British industries.

The 1820's witnessed a significant revival of linen production in Belfast, compensating for the contraction in the cotton and some minor industries. During this period, technical innovations and commercial and production reorganization within the linen industry greatly improved its efficiency and competitive position. The industry was, therefore, in a very good position to exploit the growing demand for its products.

The early 19th century saw a great increase in flax imports and as Belfast was the chief port in Northern Ireland it was an attractive location for the flax spinning industry. In 1830 the first steam-powered mill was established in Belfast and in a short space of time many similar mills were erected or converted from cotton spinning. The demand for coal imports consequently increased, and as a port Belfast's attraction as a favorable location for flax spinning increased. Entrepreneurs in Belfast and vicinity were quicker to utilize the improved methods of spinning than those in other traditional spinning areas in Northern Ireland. Consequently, because of their lower production costs the Belfast mill owners were able to undersell the individual hand spinners, who, as a result, steadily decreased in number. Belfast was therefore in a position to increase in importance as a center of spinning. In the short space of fourteen years the number of power-operated spindles increased from practically none to 155,000 spindles in 1844.[15] Belfast thus became by far the chief flax spinning center in Northern Ireland.

Demand for linen remained high after 1850 and the industry continued to develop. However, the growth of the linen industry has always been characterized by periodic fluctuations in size, which reflect periodic recessions in demand for linen goods. The linen industry experienced a great boom during the American Civil War when there was a great shortage of cotton. Linen was consequently in great demand as a substitute. Demand for linen, in general, remained high until 1875

[13] "Specialized" in this paper means the antonym of diversified. See C. E. V. Leser, *Some Aspects of the Industrial Structure of Scotland* (Edinburgh, 1951).

[14] T. Smyth, *Smyth's Directory to Belfast and Its Vicinity* (Belfast, 1819).

[15] R. Kane, *The Industrial Resources of Ireland* (Dublin, 1844), p. 320.

but during the last quarter century the demand fell and the industry was in a depressed state.

In the 1850's and 1860's there was a great changeover from hand-loom to power-loom weaving which greatly increased production and reduced costs. Weaving factory owners in Belfast, like the spinning mill owners in the city earlier in the century, quickly adopted the various technical advances made in production methods. The linen-weaving industry in Belfast was consequently in a far better competitive position than it was in other parts of the province. In the less progressive and less favorably located areas, especially mid-Antrim, southeast-Londonderry, and east Tyrone, the linen industry declined in importance, and this resulted in a significant relative increase in the importance of Belfast as a center of the linen weaving industry in Northern Ireland.

As a result of the rapid expansion of United Kingdom trading connections in the 1840's there was a significant increase in the demand for ships. But not until the arrival in Belfast, in 1851, of a brilliant English engineer named Edward Harland did shipbuilding in the city make significant progress to exploit this demand for ships. It would be difficult to overestimate Harland's influence in increasing the rate of growth of shipbuilding in Belfast, for his firm, later to be known as Harland and Wolff, has been since the 1850's by far the greatest builder of ships in the whole of Ireland.

Harland's decision to stay in Belfast and buy his own shipyard, which he did in 1859, was chiefly influenced by the fact that Queen's Island, on which the shipyard was sited, had a long clear frontage which allowed the largest vessels to be freely launched. Belfast was also favorably situated at the sheltered end of Belfast-Lough and within convenient distance of Liverpool, where Harland had valuable contacts among shipping firms. Eventually Belfast became known as the shipyard of Liverpool. There was also in the city a plentiful supply of male labor, which kept pace with increasing demand for workers as Harland's firm expanded.[16]

In 1879 a subsidiary of the large British shipbuilding firm of Workman and Clark was established in Belfast. It was attracted to the city chiefly by the prospect of finding there a suitable supply of skilled labor trained by Harland and Wolff. This contrasts with the dominance of the physical factor which mainly influenced Harland's choice of Belfast as a location for his enterprise. The growth of these two large shipbuilding firms contributed greatly to the growing concentration of industry in Belfast.

The year 1880 witnessed the founding of engine and boiler shops by Harland and Wolff. Thus this vertical integration, made to lower production costs, led to the birth of the marine engineering industry in Belfast. In the years which followed, the industry achieved much eminence and importance.

At the close of the 19th century linen was by far the dominant industry in Belfast but by that time the shipbuilding industry had also developed into a major

[16] D. Rebeck, *The History of Iron Shipbuilding on the Queen's Island, Belfast to 1874.* An unpublished Ph.D. thesis, Queen's University, Belfast, Northern Ireland, 1950.

industry. The linen industry employed chiefly females, while only males were employed in shipbuilding. The complementary nature of employment in these two major industries has been of great significance in influencing the prosperity of Belfast.

Between 1850 and 1900 development in Belfast's minor industries varied greatly. But changes in their size did not have any appreciable influence on manufacturing as a whole in the city. The growth of industry in Belfast during this period provided an impetus to the development of ancillary industries, such as general engineering and chemical industries. The tremendous increase in the city's population from 80,000 to 350,000 inhabitants in the last fifty years of the 19th century[17] stimulated the growth of consumer goods industries. Changing habits and tastes of the people also contributed to the development of such industries as those which made soft drinks, bakery-made bread and cookies, and ready-made clothing. In 1900, therefore, Belfast had a number of small yet growing industries, some of which were later to develop into major industries of great importance. Despite their small size they introduced a great measure of stability into the local economy by diversifying its specialized industrial structure. In addition, they added to the city's lead as the main center of manufacturing in the province. A common characteristic of most of the industries in Belfast was their dependence on imported raw materials. The major industries exported practically all their production,[18] but the minor industries at that time were dependent on Northern Ireland or local markets.

INDUSTRIAL DEVELOPMENT IN BELFAST 1900–29

Manufacturing industry in Belfast during the 20th century shows a long period of increase in size, but its growth is characterized by periodic sharp fluctuations in employment levels. In the early years of the 20th century the linen industry began to recover slowly from the depressed state it was in at the end of the previous century. The recovery was greatly accelerated in 1906 and 1907 as a result of a world-wide expansion of credit. A financial collapse in the U.S.A. in 1907 ended this credit expansion and one of the consequences was that the demand for linen fell sharply. In 1908 there was therefore an acute depression in the industry, but demand for linen revived in the following year and grew steadily until the outbreak of war in 1914.[19] The war led to the contraction of overseas exports on which the Northern Ireland linen industry depended, but the demand for linen by the British Government more than compensated for the loss of overseas markets, and the linen industry expanded to an all-time peak production level in 1918. In the immediate post-war period, there was a marked reduction in demand for linen which led to a contraction in the industry. Demand revived again in 1920, and production rose to a level comparable to the highest peak reached during the war, but this was short lived. Despite short periods of prosperity the linen industry in Belfast as well as

[17] E. R. R. Green, *op. cit.*, p. 126.

[18] A very significant part of total exports went to foreign countries.

[19] W. J. Larmor, *Effects of the Late War on the Linen Industry in Ireland.* An unpublished M. Com. Sc. thesis, Queen's University, Belfast, Northern Ireland, 1923.

in Northern Ireland as a whole declined after the first world war, largely as a result of increased competition from other linen producing areas and other types of textiles, as well as through a lowering of the general level of demand for linen. Other textile industries located in Belfast, such as making-up, bleaching and finishing, did not suffer to the same degree, as they were able to obtain more work from Lancashire cotton firms to compensate for the fall in the amount of linen they formerly handled.

Mention must be made of the rope-making industry in Belfast which was virtually composed of one firm employing 3,500 workers in 1920. This industry was able to hold its own in the years following the end of the first world war because of its very strong competitive position.

Shipbuilding, Belfast's other major industry, greatly benefited from the great boom in shipbuilding at the beginning of the 20th century.[20] The total production of the city's two shipbuilding firms increased from 89,884 tons in 1891 to 154,841 tons in 1903. Harland and Wolff usually made two-thirds of the total output. In 1914 the two firms produced a total of 250,000 tons of merchant shipping and employed 29,000 workers. This high level of activity was maintained throughout the first world war. But after 1918 shipbuilding contracted quickly, chiefly because of the world-wide trade depression. Increased competition from other countries, especially Germany and Japan, also adversely affected the industry. As a result, the shipbuilding industry in Belfast encountered its first major contraction since the 1850's, and in 1926 there were only approximately 5,000 workers employed in the Belfast shipyards. Despite the fact that 20 percent of the world's merchant fleet was laid up in 1928, conditions improved and in 1929 there were some 11,000 persons employed in shipbuilding in Belfast.[21]

By the close of the 19th century all the large and well-known Belfast engineering firms of Northern Ireland origin were in existence and firmly established. They continued to grow in the 20th century and most of them were able to compete in markets in Great Britain and other countries overseas. These various engineering firms produced large quantities of diverse products, such as textile and tea machinery, steam engines, boilers, tools, and a wide range of mechanical appliances. The application of electricity led to the growth of the electrical engineering industry in the early years of the present century, and electric fans and driers made in Belfast soon acquired a world-wide reputation. Although these industries were small, they were nevertheless important as there was a growing demand for their output. Their development also held promise of introducing, in the future, a greater measure of stability through the diversification of Belfast's industrial structure.

Other industries in Belfast, such as clothing, food processing, soft drink, printing and publishing, also made fairly steady progress during the first 30 years of the present century. In the same period, some industries, such as brewing and distilling, declined despite an increase in the demand for their output. They could not

[20] C. H. Oldham, *History of Belfast Shipbuilding* (Dublin, 1910).

[21] Information from the firm of Harland and Wolff.

compete with their more favorably located counterparts in Britain and Southern Ireland.

THE "GREAT DEPRESSION"

The severe slump which started in the United States in the autumn of 1929 had serious repercussions not only on industry in Belfast but on the Northern Ireland, British, and other economies in various parts of the world. This fact served to emphasize the interdependence between many national economies. Because the United States was a large market for linens produced in Belfast, a cut in American imports had a quick and severe direct effect on the city's linen industry. The indirect effect of the American slump, however, was far greater than its direct effect, for it led to a world-wide contraction of trade.[22]

A significant part of Belfast's industrial output was sold in Great Britain and abroad, and as all these markets had suffered from the effects of the "great depression," the demand for Belfast-made products fell everywhere, causing a contraction in the city's major industries. Industry in general in Northern Ireland was similarly affected, and consequently the adverse conditions in the large export industries led to a reduction in the general prosperity of the economy. There was, therefore, a resultant contraction in the activity of some industries which produced chiefly for the Northern Ireland market. These industries were mainly concentrated in Belfast.

Some Belfast industries found that the demand for their products in foreign markets was falling largely on account of the impetus which the depression and continuing world tension gave to economic nationalism. This is a factor which has continued to grow in importance to the present day. Among those Belfast industries most adversely affected by the growth of economic nationalism in the early 1930's were shipbuilding[23] and textiles. In the three years between 1929, the beginning of the slump, and 1932, when the depression was at its height, employment fell in Belfast's chief industries, namely shipbuilding and engineering, linen, and clothing, by respectively 50, 16, and 15 percent.[24] Most of the other industries in the city contracted to a much lesser degree. The only important industrial group which maintained a steady expansion throughout the 1930's was the food, drink, and tobacco group. Between 1929 and 1937, for example, this group increased its labor force by about 30 percent.

Recovery began in late 1932 and continued slowly in most industries until the beginning of 1937 when there was a minor recession in world trade, and the chief industries in Belfast were again adversely influenced. In 1937 Belfast's major industries had not recovered their 1929 positions, which meant that they had not recovered from the effects of the great depression before feeling the contracting impact of yet another recession. But, under the stimulus of the rearmaments drive, the contraction of the large industries in the city was partly compensated for by the

[22] See C. A. R. Crossland, *Britain's Economic Problem.*

[23] The shipbuilding firm of Workman and Clark closed down permanently in 1930.

[24] Statistics used in this paragraph were obtained personally from the Ministry of Labour and National Insurance, Northern Ireland.

establishment of a large aircraft factory in late 1937. By 1939 this firm was employing 7,500 workers.

BELFAST INDUSTRY 1939–1955

With the declaration of war on September 3, 1939, the economy was placed on a war-time footing. This heralded a new phase in the development of manufacturing industry in Northern Ireland in general and Belfast in particular. After a short transitional period, economic activity in the main was controlled by the United Kingdom Government at Westminster. Production not essential to the war effort was either curtailed or the productive capacity was redirected to carry out more essential work. Large-scale transfers of such capacity and labor took place into existing strategic manufacturing industries, such as shipbuilding, other engineering and aircraft production. New munitions and ordnance industries came into being and grew quickly under the stimulus of war. In contrast, employment fell substantially in the large textile and clothing industries because their supplies of raw materials and markets were severely affected by the war. Except for a little development in a few food industries which were engaged in canning, there was very little growth in the remaining industries. Many were forced to curtail production because the government rationed raw materials and consumption. However, during the second world war manufacturing industry as a whole in Belfast increased significantly in size, and the concentrating of war production in the city's factories increased Belfast's share of total manufacturing in the province.

The changeover from a wartime to a peacetime pattern of production inevitably caused some dislocation in industry. At the end of hostilities the munitions and ordnance industries contracted. In addition, demand for naval ships fell, thus bringing about a reduction in the size of the shipbuilding and marine engineering industries, which between them employed some 30,000 persons in 1944. By 1946 this number had fallen to about 24,000 persons.[25]

Between 1945 and the end of 1951 the demand for most manufactured goods was abnormally high and this provided the chief incentive to industrial expansion. In the first few years after the war most industries experienced difficulty in obtaining raw materials. In addition, the continuation of consumer rationing retarded the rate of industrial expansion. But by 1948 supplies of raw materials were practically adequate to meet demand, and government restrictions on production were, in the main, removed. In Belfast between 1945 and 1951 there was a considerable increase in the size of the textile, clothing, food, furniture, chemical, and various small miscellaneous industries. In contrast, employment in shipbuilding decreased significantly from 18,500 to 16,000 workers between 1949 and 1951. The chief cause of the decline was a great shortage of steel. Inability to give a date when ships would be built led to the loss of orders.

Excess demand caused by the second world war, and by the continuation of many forms of rationing, was largely "worked off" by the end of 1949, and in 1950

[25] Information obtained from the firm.

and 1951 activity in manufacturing industry in general was stabilized. The particularly high level of activity experienced by industry throughout most of 1951 began to fall at the close of the year and by the early summer of 1952 production had greatly contracted in a number of industries. Conditions improved during 1953 and 1954, and in 1955 most of the Belfast industries had reached or slightly improved upon their 1951 positions. The contracting shipbuilding and growing aircraft industries were the only industries to change appreciably in size between 1951 and 1955.

ANALYSIS OF STRUCTURAL CHANGES 1930–51

Between 1930 and 1951 significant changes occurred in the size and structure of manufacturing industry in Belfast. The number employed in industry increased in that period from approximately 85,000 to 120,000 persons.[26] Some of the important changes which occurred in the structure of manufacturing in the city are shown in Table 4.[27]

TABLE 4

THE STRUCTURE OF MANUFACTURING INDUSTRY IN BELFAST IN 1937 AND 1951*

Industrial group	1935 Percent	1951 Percent
Textiles	47.0	29.2
Engineering and metals	24.0	38.8
Food, drink and tobacco	12.5	11.0
Clothing	9.0	13.0
Miscellaneous	7.5	8.0
Total	100.0	100.0

* Statistics for 1935 and 1951 are not strictly comparable but they do indicate the trends of the changes which occurred in the period.

Table 4 does not disclose the full extent of the changes which occurred in the industrial structure. A more detailed analysis reveals important structural changes within the industrial groups. The textile group altered little in size between 1930 and 1951 but declined relatively to manufacturing as a whole in Belfast. There was also a great degree of diversification in the textile group's structure. This came from an increase in the size of "other" textile industries, such as converting and making-up. These industries grew at the expense of the linen industry. In addition, the linen industry diversified its production, as shown in Table 5.

Most of the growth in the engineering group was accounted for by mechanical and electrical engineering and vehicle industries. Despite the considerable degree of diversification which was achieved in the larger industrial group between 1930 and 1951,[28] there was still a high degree of specialization in the structure of Belfast's manufacturing industry, as was shown earlier in Table 2.

[26] It is thought that these census of production figures deflate slightly the number in manufacturing in Belfast. Government of Northern Ireland, *Report on the Census of Production of Northern Ireland, 1949* (Belfast, 1952).

[27] *Ibid.* and M. D. Thomas, *op. cit.*, p. 293.

[28] This was also true of a large number of firms which by various forms of integration greatly diversified their production.

Changes in the structure of industry are usually brought about by changes in the nature of demand, which is influenced by a great variety of factors. In some cases the application of an innovation or discovery leads to important changes in the industrial structure. The 1939–45 war was the most important factor which governed the recent changes in the structure of manufacturing in both Belfast and Northern Ireland, because it did much to influence the nature and intensity of demand for manufactured goods. The war also enabled the government at Westminster to have greater control over industry and to bring about desired changes in the industrial structure to meet its war-time commitments. In the post-war period, by using various controls,[29] the government continued to have a large measure of influence on the industrial structure. This was necessary because the United Kingdom payments problem was largely the result of the war and created the need to increase exports.

TABLE 5

LINEN INDUSTRY'S PRODUCTION IN 1935 AND 1951*

Item produced	1935	1951
Type of cloth produced, percent of total:		
Linen and union	97.5	53
Cotton and cotton/rayon	2.5	9
Rayon		37
Other materials		1
Total percent	100.0	100
Total in thousand sq. yds.	149,882	187,402
Type of yarn, thousand cwts.:		
Flax	579	445
Spun rayon		228

* These statistics apply to the linen industry of Northern Ireland. However, field work and information from the head of the Census of Production in Northern Ireland indicate that the pattern of change also holds true for Belfast. Source: Government of Northern Ireland, *Report on the Census of Production of Northern Ireland,* 1951 (Belfast, 1954). Calculated from statistics on p. 39.

In addition to the influence of changes in demand, the structure of manufacturing in Belfast and in Ulster as a whole was also affected between 1932 and 1951 by specific action on the part of the Northern Ireland government.

Although the province is not officially classified as a Special Development Area, it has had over a long period many of the features typical of such areas in Britain—for example, over-specialization in a few large industries and persistently high unemployment rates.[30] In the early 1930's when the chief industries, namely linen and shipbuilding, simultaneously suffered a severe slump "it was evident that the Province's industrial structure was most insecurely founded."[31] In the light of this conclusion,

[29] These controls were imposed on consumer demand and on production of goods.

[30] Since 1946, for example, unemployment has never fallen below 5 percent of the total working in manufacturing while in Great Britain unemployment has been around 2 percent.

[31] *Ulster Year Book,* 1949 (Belfast, 1949), p. xxxviii. Although this remark and the one following were made in reference to Northern Ireland as a whole, they were particularly pertinent to Belfast.

> . . . the (Northern Ireland) Government accordingly adopted a policy designed to secure a stronger, and at the same time, a more flexible industrial structure by encouraging the establishment of new types of industry. To achieve its object of diversification and development of industry the Government (N.I.) introduced legislation designed, not only to promote the establishment of new industries in the Province, but also to encourage the expansion of existing industries. In all, seven Acts of Parliament (N.I.) have been passed for this purpose: the Industrial Development Acts of 1932, 1937 (two Acts), 1942, 1944, 1945, and 1948.[32]

The most important Industrial Development Act was that passed in 1945, which was designed to "achieve a quick conversion from wartime to peacetime production."[33] This act provided a far greater range of facilities and aid than previous acts.[34] The powers are wider than those contained in British industrial development acts and the Northern Ireland Ministry of Commerce[35] also goes much further in the application of the powers.[36] An increase in employment has been the primary objective of government industrial policy since 1945. This contrasts with the chief objectives of earlier acts, particularly the 1932 Industrial Development Act, which aimed at the diversification of industry in order to achieve greater stability. Ministry of Commerce officials say that they still do all they can to encourage the growth of industries which are new to the province.[37]

It is very difficult to measure accurately the influence of the government of Northern Ireland in bringing about recent changes in the structure of manufacturing industry in Northern Ireland in general and Belfast in particular. The present writer believes that the government of the province has played an important part in assisting and even accelerating changes which took place in the industrial structure. But the role of the government has been of secondary importance in comparison with the influence generated by changing patterns of demand so characteristic of the second world war and post-war periods.

The contribution made to the stability of manufacturing in Belfast by structural changes has been greatly supplemented by the increasing dependence of industry, in recent years, on the British market. Before the 1930's manufacturing in Belfast and in the rest of Northern Ireland for that matter was dependent to a considerable degree on markets outside the United Kingdom, and in many cases this proved to be an unstable element. However, if Belfast and the rest of the province are to retain such a large manufacturing industry in comparison with the existing size of population, the industrial surplus must be disposed of outside Northern Ireland. A stabilizing feature in recent years was introduced into the industrial structure by

[32] *Ibid.*

[33] *Ibid.*, p. xxxix.

[34] See pp. xxxviii-xl in *Ulster Year Book*, 1949, for the various incentives offered to industry by the government of Northern Ireland.

[35] In Northern Ireland the Ministry of Commerce administers the acts. It has a special department which is concerned with "industrial development" and is a source of great help to industry in general.

[36] Personal information from the chief official in the Industrial Development Department.

[37] Personal information.

the growth of industries which were largely dependent on the British and Northern Ireland markets. In 1951 Britain took more than 50 percent of the total industrial output while only some 16 percent was sold to foreign countries.[38] This great dependence on the "home" market tends to stabilize industrial activity because the Westminster government, and to a lesser extent the Northern Ireland government, have a measure of control over home demand in a recession. They can temporarily stimulate economic activity by stock-piling textiles, clothing, and foodstuffs for the Armed Services and by other short-term methods.

BELFAST AS A CENTER OF MANUFACTURING IN THE PROVINCE

The widespread distribution of unemployment in Northern Ireland is a great social as well as an economic problem. The government seeks to solve these problems by fostering the growth of industry in all parts of the province. In addition, the government wishes to disperse industry more evenly throughout Northern Ireland.[39] With these objectives in view it seeks to encourage[40] industrialists to establish their enterprises in areas outside Belfast and more especially in the less industrial counties of Fermanagh, Londonderry, and Tyrone. Table 6 reveals, however, that despite government efforts to disperse industry more widely throughout the province, and especially its attempts to locate new industry outside Belfast, the city still dominates the distribution of manufacturing in Northern Ireland.

As mentioned earlier in this paper, great industrial development took place in Northern Ireland in recent years. The existing factories were not able to satisfy demand. This led to the erection of new factories and to the extension of many existing plants. The high demand for goods not produced in Northern Ireland and which could not be manufactured in existing factories provided an incentive to build new establishments or to begin production in suitable unoccupied buildings.

Between 1930 and 1951 there was an increase of some 60,000 persons in the number of employed in industry in Northern Ireland and approximately 35,000 of this total was accounted for by Belfast factories.[41] At the end of 1952 there were 21,708 persons employed in government-assisted undertakings[42] and this was only about a third of the total increase in the number employed between 1932 and 1951. Because there were very few factories built without government assistance, the location of the state-aided undertakings indicates where the chief changes in the distribution of industries occurred in this period. Most of the total increase in employment was accounted for by firms which were in production before 1932. Many of these extended their plants in the subsequent period, but in the main the extensions were made at the same site. Increases in employment in these long-established

[38] Personal information from the Ministry of Commerce, Northern Ireland.

[39] Government of Northern Ireland, *Ulster Year Book, 1949* (Belfast, 1949), p. xxxviii.

[40] The government cannot use compulsory measures when attempting to influence the location and siting of new firms.

[41] *Ibid.*, p. 5.

[42] *Ulster Year Book, 1953* (Belfast, 1953), p. 113.

factories were fairly evenly distributed throughout the province.[43] Consequently they caused little change in the relative density of industrial employment in the various regions or in the distribution pattern of factories in Northern Ireland between 1930 and 1951.

The distribution of government-aided factories established between 1932 and September 1953 is shown on Figure 1. Some 68 percent of these 153 new undertakings were situated outside Belfast.[44] In addition, the majority of the factories erected in the same period without government help were also located outside the city. However, because the factories established in Belfast were on an average bigger, they employed 55 percent of the total 21,708 persons engaged in the government-aided factories in December 1952.[45] Therefore, the establishment of new fac-

TABLE 6

THE LOCATION OF INDUSTRY IN NORTHERN IRELAND IN 1935 AND 1951*

County or County Borough	Percent of total number employed		Percent of total net output	
	1935	1951	1935	1951
Belfast County Borough	61.6	56.7	68.6	58.8
Londonderry County Borough	5.1	5.2	4.2	4.9
County Antrim	12.0	12.6	9.7	12.4
County Armagh	7.1	7.9	5.3	6.7
County Down	7.0	7.5	5.0	6.3
County Fermanagh	0.4	0.7	0.3	0.7
County Londonderry	1.4	1.9	1.2	2.1
County Tyrone	3.0	4.1	2.2	4.3
Not separately distinguished	2.4	3.3	3.4	3.8
Total	100.0	100.0	100.0	100.0

* Industry in this table is made up of manufacturing, building, civil engineering, gas, electricity, water, and laundry industries. Source: *Report on the Census of Production of Northern Ireland,* 1951 (Belfast, 1954), p. 8.

tories—government-aided and non-government-aided—detracted but little from the concentration of manufacturing in Belfast, which in 1951 still had 58 percent of the total employed in industry in Northern Ireland.

The reasons for Belfast's continued dominance as a center for manufacturing may be found in its attractions as a location for industry. In considering the factors which have influenced the location of industry in the period 1930 to 1953 it is necessary to differentiate between factories which were established before 1930 and those established since then. Undertakings which existed before 1930 have retained their former sites in the succeeding period, primarily because there has been no significant

[43] This conclusion is reached from the study of changes in the geographical distribution given on a county basis in the *Census of Production for Northern Ireland,* 1951, supplemented with confidential information obtained in the course of carrying out research in the region.

[44] The Ministry of Commerce kindly provided the author with information necessary to plot the distribution of the new undertakings.

[45] *Ibid.,* p. 113.

change in the factors governing their location to justify change. The cost of moving a plant is a sufficiently strong deterrent to changes in location unless there are very important changes in the influence of some locational factors.

Belfast has continued to attract new undertakings because approximately half the total population of Northern Ireland in 1951 was concentrated within 20 miles of the city. In addition, on June 18th of the same year, this region contained 62 percent of the total unemployed in manufacturing, and 47 percent of the total unemployed in all industries in the province.[46] Labor in Belfast and vicinity has also the widest range of industrial skills. Most firms could therefore satisfy their labor requirements in Belfast or in its immediate vicinity. The largest and most important new factories established in Belfast in recent years have been engineering firms[47] of various kinds, and it is significant that they have been established in the traditional engineering center in Northern Ireland. Belfast as the main port provides additional attractions to the larger new factories because most of them import practically all their raw materials and export the greater part of their output. As the center of such a large population concentration and because Belfast is the focus of a fine provincial communications network, it has also attracted many new-market oriented factories, which are usually small in size but produce a variety of goods, such as plastics, jam pot closures, artificial flowers, sauces, toys, and paper bags.

In addition, the government of Northern Ireland has contributed greatly to the concentration of new factories in Belfast and its neighborhood by locating its two main industrial estates on the northern and southern boundaries of the city. It is difficult to see in the light of Belfast's present lead and continuing attractions as a location for manufacturing industry how the government hopes to reduce in the near future the overwhelming concentration of industry in the city or its immediate vicinity.[48]

CONCLUSIONS

The growth of Belfast's major industries has been primarily influenced by economic and political conditions outside the province, chiefly because these industries have always been dependent on external markets. In the 20th century two world wars provided tremendous impetus to the development of manufacturing in the city. Belfast's industrial structure is largely the product of the 19th century when specialization was in vogue. Northern Ireland's lack of raw materials and its abundant supply of cheap yet adaptable labor greatly influenced the type of industry suitable for development. It was of vital importance to have external markets in order that the few large-scale industries could remain competitive. Such markets, often widely dispersed and at a considerable distance from the province, as well as

[46] Personal information from the Statistical Office, Ministry of Labour and National Insurance, Northern Ireland.

[47] The large aircraft manufacturing firm of Short and Harland is included in this category.

[48] Field work indicates that it is becoming increasingly difficult and extremely costly to find building space in the city itself but as seen in Figure 1 the areas near Belfast are proving to be very attractive to the location of new factories.

the need to import the major part of the raw material requirements, imposed additional costs on industry. Consequently, Northern Ireland in general and Belfast in particular developed industries whose labor requirements were high or had high conversion ratios. In most cases, transfer costs form but a small proportion of the total costs of Belfast's chief industries. In the minor industries, where such costs are often high, the products are usually sold in Northern Ireland.

Because Belfast's major industries form such a large proportion of total industry in Northern Ireland, and because they are subject to periodic recessions, they introduce a considerable measure of instability into the economy, and resulting unemployment causes much distress. Since 1932, the Northern Ireland government has made great efforts to diversify the industrial structure and in many ways the government is helping to achieve this objective. In addition, industrialists are responding to changes in general demand patterns and new industries are being developed for whose products there is a growing demand. Nevertheless progress in this direction is slow. The great dependence of Belfast's major industries on imports of raw materials and on export markets tends to make them still vulnerable to external forces. However, if these industries are to maintain their present size then they must export. The growing importance of the British market in recent years has therefore introduced a greater measure of stability.

The growth of Belfast as a center of manufacturing has been greatly influenced by the fact that the city has long had a good supply of enterprising entrepreneurs. No doubt the easy and frequent contact between the people in this part of Northern Ireland and the more highly developed and industrialized parts of England and Scotland across the Irish Sea has also had inestimable effect on the development of industry in many parts of the province, especially in Belfast. As a port and growing focus of communications, and center of population, Belfast early demonstrated that it was the most favorable location in Northern Ireland for industry. Most industries were greatly dependent on imported raw materials. The city and its immediate neighborhood always had a good supply of suitable labor. Today, labor is the chief factor influencing the location of new industries in Northern Ireland. The Belfast district has the greatest concentration of labor with the widest range of skills. In addition, the city is the dominant center of population and industry in the province and these factors further enhance its attraction as a location for new-market oriented and ancillary industries. In the foreseeable future, therefore, Belfast is assured of maintaining its dominance as a center of manufacturing in Northern Ireland.

MAN AS A GEOMORPHOLOGICAL AGENT: THE EXAMPLE OF COAL MINING

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GEOGRAPHERS, geomorphologists, and geologists have probably long recognized that man is a geomorphological agent, but they have been remiss in publishing analytical studies of man's influence on landforms.[1] Some of man's *physical* landscape alterations are dramatic in impact, whereas other effects are far more subtle and difficult to observe. A complete examination of man's geomorphological influences is a stupendous task. It is not the purpose of this paper to investigate all the ways in which man acts as a geomorphological agent.[2] Rather our purpose is to describe the effects of coal mining in the United States upon landforms and associated phenomena.[3]

[1] A random inventory of geology, geomorphology, physiography, and physical geography books reveals that most authors ignore man as a geomorphological agent. Among these are: Philip Lake, *Physical Geography* (rev. and enlarged by J. A. Steers, G. Manley, and W. V. Lewis, 3rd ed.; Cambridge University Press, 1952); S. W. Wooldridge and R. S. Morgan, *The Physical Basis of Geography* (London, 1937); Fritz Machatschek, *Das Relief der Erde* (Berlin, 1938); Emmanuel de Martonne, *Traite de Geographie Physique* (Paris, 1920); C. A. Cotton, *Geomorphology* (5th ed.; New York, 1949); O. D. von Engeln, *Geomorphology* (New York, 1942); A. K. Lobeck, *Geomorphology* (New York, 1939), Norman E. A. Hinds, *Geomorphology* (New York, 1943); Vernor C. Finch and Glenn T. Trewartha, *Elements of Geography* (3rd ed.; New York, 1949); Henri Baulig, *Essais de Geomorphologie* (Paris: Societe D'Edition, Les Belles Lettres, 1950.) This situation is understandable, in part, since space limitations probably precluded a treatment of man as a geomorphological agent. Not so understandable, however, is the failure of S. W. Wooldridge to mention man as a geomorphological agent in his chapter, "The Progress of Geomorphology," in Griffith Taylor's *Geography in the Twentieth Century* (New York: Philosophical Library, 1951). Similarly Louis C. Peltier failed to mention man as a significant geomorphological agent in his chapter on geomorphology in Preston E. James and Clarence F. Jones (eds.), *American Geography, Inventory and Prospect* (Syracuse University Press, 1954). In addition, an examination of the rather lengthy series of references listed at the end of his chapter fails to reveal any which deal with man's influence upon landforms.

An early reporter of man's geomorphological role was R. L. Sherlock. His *Man as a Geological Agent* (London, 1922) is an excellent work for its time and place. Unfortunately, however, the work is over thirty years old and covers a period when earth-moving equipment was still ill-developed. Further, the book treats the influence of man on the physical landscape only in Britain. Recently a geomorphologist has taken an oblique view of man's influence upon the physical landscape. William D. Thornbury, *Principles of Geomorphology* (New York, 1954) makes passing reference to man's landscape modification in local areas.

[2] The authors do, however, look toward the time when they may be able to unravel an additional segment of this complex problem.

[3] Why coal? A quotation from Jean Brunhes, *Human Geography* (abridged edition by Mme. M. Jean-Brunhes Delamarre and Pierre Deffontaines, translated by Ernest F. Row; New York, 1952) used in a different connotation nevertheless answers this question very well: "It is natural to select for fuller treatment, and as an example of the brief special study, the

To this end it is necessary to inventory the mining regions from an areal standpoint, to recount the geomorphological effects of coal mining, specifically, where practical, and otherwise qualitatively, to postulate concerning coal mining-geomorphological relationships, and to speculate concerning the future course of coal mining and its influence upon the physical landscape.[4]

Common-sense hypothesis and later field verification disclosed that the influences of underground mining and strip mining on the physical landscape, while both distinctive, are separate phenomena. Hence the influences of underground and strip mining are discussed separately. Further, field investigations verified previous suppositions that landform features resulting from coal mining are far more conspicuous in an area of low initial relief. Mountainous regions are initially so gross in relief that immediate mining influences are little more noticeable than a mole hill on a level plain. It should be remembered, however, that subtle influences are evident and can be detected even in rugged terrain. Finally, it is obvious that the imprint of mining upon the landscape is becoming more significant as man continues to meet the coal fuel needs of the United States.

LOCATION OF PAST, PRESENT, AND FUTURE COAL MINING AREAS

At present coal is mined in commercial quantities in twenty-eight states and more than four hundred counties.[5] Thirty-seven counties each produced more than 5,000,000 tons in 1952.[6] Each year, approximately 500,000,000 tons of coal are removed from beneath the surface along with countless tons of waste rock and debris.[7] Of this total, about four-fifths is produced east of the Mississippi River (Fig. 1). Obviously, then, coal mining has had a more significant geomorphological influence in the eastern part of the United States than in western sections. However, the locus of coal production will probably continue its westward shift because of increased western fuel demands and an eventual depletion of eastern coal re-

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most imposing type of mineral exploitation, the one that forms the foundation of all industrial development to-day, and the one that has given rise to such intense economic activity that it has often been studied as a strictly economic subject." (Quoted from page 163.)

[4] Unfortunately certain limitations prevent absolute and complete accomplishment of these stated objectives. For example, incomplete and inaccurate accounts were kept of early-day coal mining. In addition, some strip mine areas have been leveled and subsidence has ceased in many old shaft mining regions. In short, many areas will illustrate the geomorphological effects of coal mining, while a few will not. Hence it is only partially practical to use the most current figures for coal mining areas, since some of the areas of coal mining show great landform influences, some a moderate amount, and a few are almost imperceptibly modified. Obviously, too, other mining areas, now abandoned, leave behind symbols of man's influence on the physical landscape.

[5] Data obtained from *Minerals Yearbook, 1952,* Vol. II, *Fuels,* Bureau of Mines, Department of the Interior, p. 99 and following.

[6] *1953 Bituminous Coal Annual,* Bituminous Coal Institute, Washington, D. C., 1953, p. 53.

[7] This is an approximate average over the past ten years or thereabouts. Data obtained from *Minerals Yearbook, 1952, op. cit.,* p. 99 and ff.

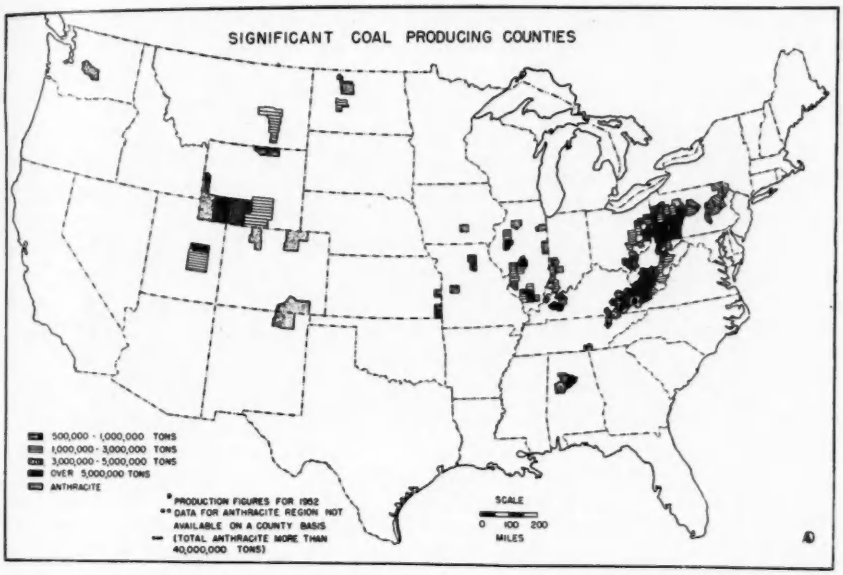
SIGNIFICANT COAL PRODUCING COUNTIES
500,000 - 1,000,000 TONS
1,000,000 - 3,000,000 TONS
3,000,000 - 5,000,000 TONS
OVER 5,000,000 TONS
ANTHRACITE
* PRODUCTION FIGURES FOR 1952
** DATA FOR ANTHRACITE REGION NOT AVAILABLE ON A COUNTY BASIS (TOTAL ANTHRACITE MORE THAN 40,000,000 TONS)
SCALE
0 100 200
MILES

FIG. 1. Significant coal producing counties (Production data from *Minerals Yearbook*, 1952, Vol. II, *Fuels*).

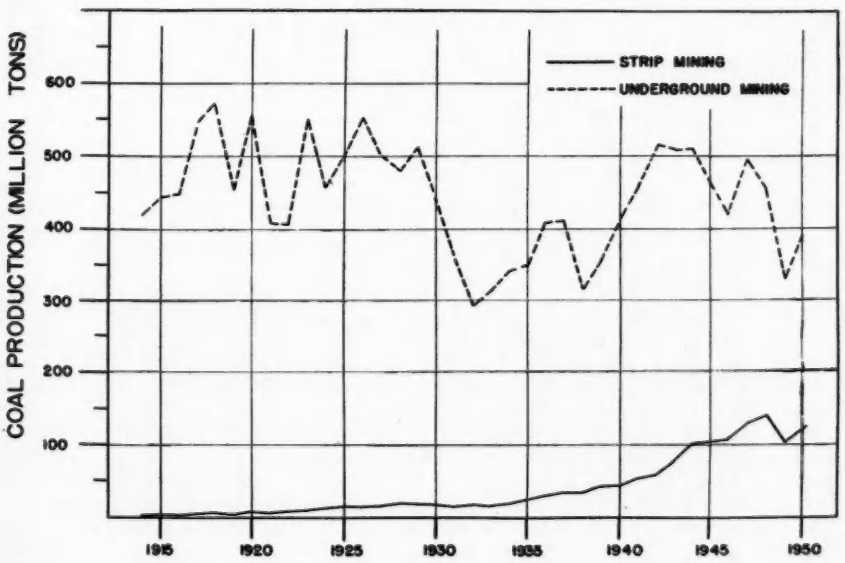

FIG. 2. Relative production of coal by underground mining and strip mining.

serves.[8] As coal production expands geographically the influence of man upon the physical landscape will become more widely recognizable.

GEOMORPHOLOGICAL EFFECTS OF UNDERGROUND COAL MINING

Underground coal mining has always been of much greater significance than surface mining. In recent years, however, surface mining is becoming increasingly important (Fig. 2). While strip mining has had a more noticeable geomorphological significance, underground mining has had, and will continue to have, considerable geomorphological importance. Landform features resulting from underground mining are conspicuous landscape features in areas of heavy production.

Soon after mining has begun small mounds or hillocks, composed of waste rock or slack,[9] are formed. These hillocks may be conical or oriented along a longitudinal axis (Figs. 3 and 4). These mounds of waste materials vary considerably in height depending upon the size of the mine, quality of the coal, and the lateral extent of the land used for the refuse pile.[10] Piles of refuse arranged along longitudinal axes are commonly about twenty feet high, and occasionally may be as high as forty feet. On the other hand, if all the waste material is piled in the same place the resultant conical shaped hill (in general appearance much like a small parasitic volcanic cone, and certainly as noticeable as a kame) may reach heights of 75–100 feet.

The refuse piles which are oriented along longitudinal axes tend, after a short time, to develop swampy pockets in the space between succeeding ridges. These marshy areas are transitory and disappear with dry weather. Sides of the ridges are rapidly gullied and minute alluvial fans are deposited on adjacent flatter areas. Some of the hillocks disappear quickly, but one of the authors has observed sizeable ridges still in existence after fifty or more years.

The cone-shaped hillocks develop a miniature radial drainage pattern, and, as years progress, begin to look increasingly like a small eroded cinder cone. Since both the cone-shaped and longitudinal hillocks contain poisonous wastes they often remain without vegetation for twenty or thirty years. In addition, toxic materials carried to adjacent areas may poison vegetation and eventually result in accelerated erosion in these contiguous areas.

[8] Raymond E. Murphy and Hugh E. Spittal, "Movements of the Center of Coal Mining in the Appalachian Plateaus," *Geographical Review*, Vol. 35, pp. 624–633. These authors notice the shift of the locus of production in the Appalachian Plateau in a southwestward direction, and they likewise sound a note of warning about the dwindling Appalachian coal reserves.

[9] Slack refers to very fine waste coal which is not commercially usable where briqueting facilities are unavailable.

[10] The authors have observed these hillocks of waste material in coal mining areas of Washington, Utah, Colorado, Oklahoma, Illinois, Indiana, Kentucky, Tennessee, West Virginia, and Ohio. These hillocks have been reported by others as well. R. E. and Marion Murphy, "Anthracite Region of Pennsylvania," *Economic Geography*, Vol. 14 (1938), p. 338, report: "From the mine openings great piles of waste are growing. Some appear as symmetrical cones, but others, the great majority, are elongated with a trend similar to that of the ridges and like them tend to show evenness of summit level."

FIG. 3. Conical shaped hillock of waste coal and rock from underground mine. Note that the hillock resembles a small cinder cone. This hillock is about 75 feet high.

Waste materials which are burned at the surface produce noxious fumes, and as these fumes combine with atmospheric moisture they may produce sulphurous or sulphuric acid which will destroy vegetation within the immediate vicinity. Occasionally underground mines will start to burn and must be sealed up. Eventually, if the coal seam is near the surface, smoke and sulphurous fumes will issue from the ground in a fashion not unlike that of fumaroles.

Other geomorphological effects are associated with subsidence, or man-induced

FIG. 4. Waste from underground mine arranged along a longitudinal axis. The waste coal has been set ablaze. Height of this ridge is about 25 feet.

faulting. "Squeezes" resulting from the collapse of a mine roof may cause earthquake-like tremors. Such minor tremors are frequently felt in areas of underground mining and occasionally a sharp jolt is felt.

The effects of squeezes are instantaneous and at the same time permanent. After the squeezes, cracks may appear at the surface, small hills may disappear, swamps may be formed, and drainage may be temporarily deranged (on rare occasions permanently deranged).[11] In short, this man-induced faulting may result in many of the features associated with normal diastrophic faulting.

Other more subtle changes which occur in underground workings are due to exposure of subterranean strata to the atmosphere. Undoubtedly the rate of weathering is increased, which probably facilitates subsidence. When mine pillars have weathered away continued settling may alter physical and cultural surface features radically.

HISTORY AND TECHNIQUES OF STRIP MINING

The strip mining of coal began more than one hundred years ago. The first diggings were made by pick and shovel; later animal-drawn slip scrapers were used. Only outcropping coal or seams covered by thin soft overburden could be mined by these crude methods. Obviously shallow mining and crude implements left little geomorphological imprint upon the land. About the turn of the century steam shovels were used in scattered areas. In 1914 stripping was responsible for the removal of 0.3 percent of the coal mined in the United States, but this percentage had increased to almost 25 by 1949 and there were 1,761 strip pits operating in more than 220 countries of this country during that year.[12] Larger equipment, introduced to increase strip mine production, has left more distinct topographic marks on the landscape.

During the past two or three decades some of the largest earth-moving equipment in the world has been used to remove overburden from above coal seams (Fig. 5). Today, practically all strip coal mining is done on a large scale by electric or Diesel-powered shovels and draglines. The removal of coal is a relatively simple process, and the procedure is nearly uniform throughout the United States.

The first cut is made at an outcropping seam of coal in hilly terrain, or at the limit of the leased or purchased property on level terrain. The overburden from the first cut is piled on the ground next to the area to be strip mined. In some cases the dragline simply digs down to the coal seam. In other areas a large shovel and dragline work in parallel-tandem operations. In this latter operation the dragline makes no attempt to work down to the coal, and the shovel removes the remainder of the overburden. In either operation the exposed coal is loaded into trucks by a loading shovel. The coal is then taken to a beneficiation plant and marketed.

Meanwhile the dragline operates continuously. At the end of the first cut the direction is reversed and a new cut is made parallel to the first, the overburden from

[11] The authors are not alone in observing this fact. Lewis E. Young, *Subsidence in Illinois Resulting from Coal Mining*, Bulletin No. 17, Illinois State Geological Survey, Urbana, pp. 44–47.

[12] *Minerals Yearbook*, 1950, Bureau of Mines, Department of the Interior, pp. 284–296.

the new cut being dumped into the first cut from which the coal was loaded. Thus the process continues as a cut-and-fill sequence until the last cut is made. The operation of strip mining equipment is rather methodical for any given terrain, coal seam, and method of mining, and the resulting surfaces in comparable original terrain have the same characteristics.

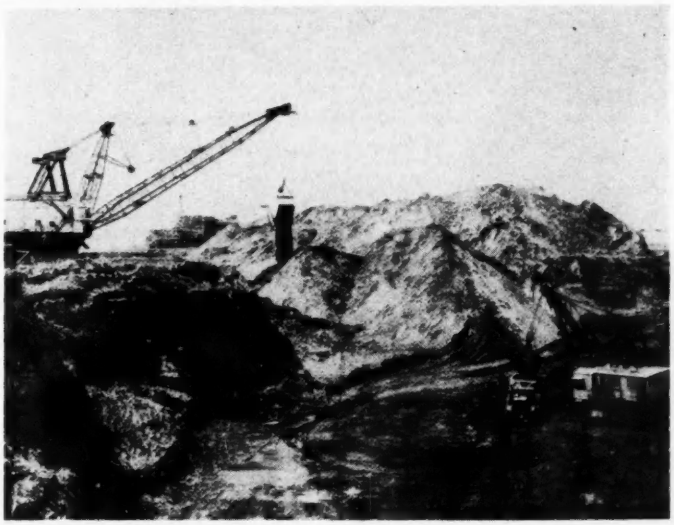

FIG. 5. Dragline equipment used in coal stripping operations.

GEOMORPHOLOGICAL EFFECTS OF STRIP MINING

Strip mining leaves the surface topography in a series of nearly parallel ridges and valleys. The actual width, height, and steepness of the ridges vary with the character and thickness of overburden, the unstripped terrain, the equipment and methods used, and the age of the banks.

When the depth of the coal seam is shallow the local relief of the stripped terrain is naturally low. The strip mining of shallow coal seams leaves a vertical distance of from two to six feet from the bottom of the valleys to the ridge tops, and the relief between the last unfilled cut and the adjacent ridge may reach 20 feet. As the spoil banks age the local relief is lessened by erosion and settling. In strip mining coal to a depth of 60 or 80 feet, ridge crests may be 50 feet apart, and the slopes are as steep as the angle of repose of the overburden.[13] This means that the

[13] These figures are based on field work carried out in southwestern Indiana and western Kentucky. In addition, these data were checked stereoscopically from aerial photographs of other strip coal mining areas in the states of Illinois, Kansas, Missouri, and Ohio. Similarly Nelson F. Rogers mentions ridges "50 feet high and with crests 40 to 100 feet apart," in 46 counties along the eastern boundary of the Western Interior Coal Province. "Strip Mined Lands of the Western Interior Coal Province," *Research Bulletin 475*, Agricultural Experiment Station, University of Missouri, May, 1951, p. 15.

FIG. 6. Large strip mine. Local relief approximates 50 feet between the highest ridge and the open cut.

ridges will have a slope measuring from 30 to 80 percent.[14] Extreme local relief of as much as 100 feet may be attained between the last unfilled cut and the adjacent ridge (Figs. 6, 7, 8).

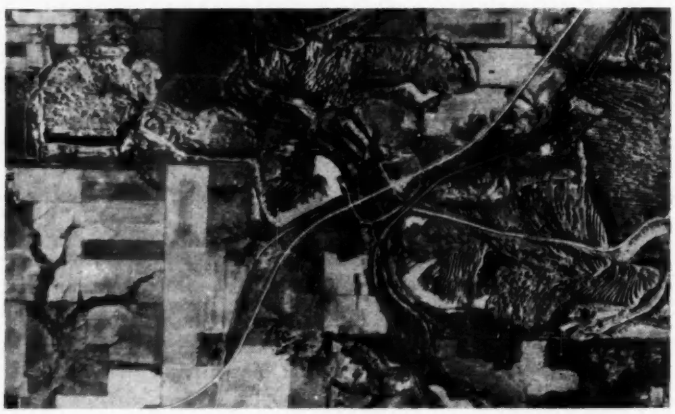

FIG. 7. Aerial view of stripping operations showing alternate ridges and valleys typical of strip coal mining. Note, too, the lakes which occupy the unfilled cuts. (United States Department of Agriculture photograph.)

[14] E. Willard Miller cites a comparable slope in western Pennsylvania in "Strip Mining and Land Utilization in Western Pennsylvania," *Scientific Monthly*, Vol. 69 (1949), pp. 94–103.

Disposal of the overburden alters the terrain more than is immediately obvious, since the volume of the excavated spoil is greater than the original volume. Consequently the spoil banks cover more land than the surface actually mined. The first ridge is piled on unstripped land, and as a result is higher than adjacent ridges. In contrast the final cut is a long deep pit with a vertical high wall on one side and a steep bank on the other.

The size and arrangement of ridges and valleys are partially determined by the mining equipment and methods. When power shovels or draglines are used singly a high proportion of the rock strata immediately above the coal seam is placed on top of the spoil. This usually creates steep, sharply serrate ridges and conical banks, which, because of their steep slope, are subject to rapid erosion.

FIG. 8. Modest local relief exhibited in shallow strip pits.

With tandem operations (those in which draglines and shovels are used jointly), the upper part of the overburden can be placed on top of the lower strata. Thus the surface spoil material has a higher proportion of soil and is more homogeneous in composition than when the dragline is used alone. However, these spoil banks are subject to excessive settling and severe erosion, in spite of the fact that their relief is less pronounced than on banks created by the single unit method. Further variation in the character of stripped land is developed because of the contiguous or non-contiguous location of stripped areas and irregular property boundaries.

Flat plains facilitate the stripping of entire blocks of land, whereas in rough dissected plains or hill lands normally only two or three cuts are made. In hilly areas, stripping is usually done on the contour. As coal seams in rough terrain usually dip into hillsides, it is practical to strip a band of only 100 to 300 feet.[15] The total length of the cut varies from a few hundred to thousands of feet. On

[15] William C. Bramble, "Reforestration of Strip-Mined Bituminous Coal Land in Pennsylvania," *Journal of Forestry*, Vol. 50, no. 4 (1952), p. 309.

rare occasions entire hill tops are removed, and the spoil banks which are piled down slope normally do not exceed 20 acres in size.

WEATHERING AND EROSION

The type of overburden which makes up the spoil banks varies considerably in different parts of the United States. Most frequently the sedimentary stratum above the coal seam is shale, and it, in turn, may be covered by other sedimentaries and/or glacial till, outwash material, or aeolian deposits. Obviously the character of the overburden is significant in weathering changes and soil formation.

The initial cut removes most of the soil and weathered parent material. As succeeding cuts are made the overburden is composed of increasing amounts of unweathered material. Stripping, in effect, turns the soil horizon upside down and caps it with rock which originally capped the coal seam. The resultant conglomeration of material is much different from the original soil type.

Material making up the spoil surfaces includes sands, silts, and clays as well as sandstone, shales, and limestones. The majority of spoil banks are composed of loamy material and silty shale. Soil accounts for only about 30 percent of the total.[16] These banks sometimes contain enough silt and clay to insure high water retention near the surface, but if rock fragments are dominant at the surface, run off and percolation are rapid.

Since material from immediately above the coal seam is usually thrown on top of spoil banks a radical change in soil acidity often occurs. Frequently the overburden contains pyritic material which breaks down on exposure to air and moisture to iron sulphates, which are, in turn, altered to sulphuric acid.[17] These acid spots usually appear as moist, roughly circular patches on spoil banks (Fig. 9). This increased acidity precludes vegetative growth and at the same time kills beneficial micro-organisms. It should be pointed out, however, that the overturned overburden is usually richer in phosphorous and potash than the original top soil of the stripped area.[18]

Since newly formed spoil banks are devoid of vegetation the bare surface lies exposed to the full ravages of weathering and erosion. Disintegration is especially rapid during the first few years after exposure of overburden with freezing and thawing, ice wedging, and burrowing causing a rapid deterioration of the surface rock material. Decomposition does not proceed as rapidly as might be supposed since there is a general absence of organic acids and the pyrites are located patchily. However, oxidation and hydration do occur with some rapidity, since newly exposed rock materials are usually not particularly resistant.

[16] Rogers, *op. cit.*, p. 18, estimates from detailed data on Arkansas, Kansas, Missouri, and Oklahoma that "30 per cent of the average bank's surface was made up of particles less than 2 mm. in diameter, 26 per cent 2 mm. to one-half inch in size, 33 per cent one-half to 4 inches in size and 11 per cent of stones larger than 4 inches." Bramble, *op. cit.*, p. 309, states that in a typical spoil bank in Pennsylvania the soil content ranges from 20 to 50 percent.

[17] Miller, *op. cit.*, p. 102.

[18] G. A. Limstrom and G. H. Deitschman, "Reclaiming Illinois Strip Coal Lands by Forest Planting," *Bulletin 547*, Agricultural Experiment Station, University of Illinois, p. 208.

It is difficult to make a generalization about the rate of weathering, since much depends on the climate, type of rock exposed, mining methods, and the absence or presence of highly sulphurous material. As a rule of thumb it can be stated that weathering is more rapid in humid areas which experience considerable temperature extremes, and where the coal or overburden is heavily laden with pyrites.

The rate of erosion is strongly influenced by slope of the spoil bank and texture of the overburden material. New spoil banks do much settling and slipping during the first five years of exposure. During this period the tops of ridges become rounded, the valleys are flattened, and the gradient of the slopes is reduced.

Increasing amounts of glacial till, loess, and alluvium increase the proportion of soil, improve the texture, and affect the erodibility of spoil bank surfaces. Valley strip mining generally results in more soil in the spoil surfaces than hillside strip

FIG. 9. Acid spots (dark patches) on the side of a spoil bank.

mining, because of the greater proportion of alluvium in the overburden. Loessal banks are prone to severe gully erosion. Spoil banks mined in areas of glacial till are generally porous and well drained. Sandy spoil banks often contain enough alluvium to give them a slush-like consistency during rainy periods, and as a result mud flows are common in this type of stripped area. Then, after drying, the sandy spoils become compact and temporarily recemented.

As a general rule it may be stated that sandy spoils erode most rapidly, and shales erode the slowest. High clay content makes the shale more cohesive than sand and hence less subject to erosion. Gravelly till tends to resist erosion, but once a gully begins on a glacial till bank it will cut rapidly.

Great quantities of earth are usually eroded away from spoil banks. In level terrain miners and farmers often establish a diversion ditch to save adjacent fields from being covered by waste eroded from stripped sections. However, when roll-

FIG. 10. Small intermittent pond which has developed in a partially graded area.

ing terrain is strip-mined, the mine waters are usually drained into a stream. Such a stream will frequently become overloaded and its normal gradient and stage in the erosion cycle will be altered. Stream pollution from dissolved chemicals is commonplace.

ESTABLISHMENT OF LAKES

Within the rough dissected topography created by strip mining, water often collects between the ridges and on partially graded areas (Fig. 10). As a result, numerous small, intermittent, shallow ponds are formed. In addition, the abandoned runways, roadways, and final cuts usually become filled with water and form lakes as much as 80 feet wide and 50 feet deep (Fig. 11). These lakes are not

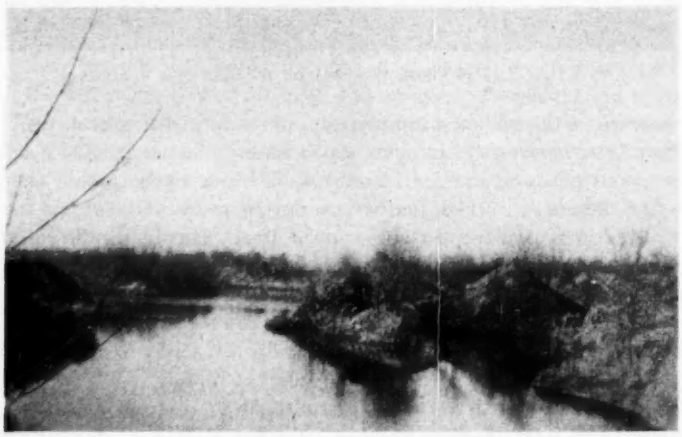

FIG. 11. Permanent lake formed in the last cut of strip mining operations.

stagnant since the water constantly circulates through the spoil banks; however, exposed coal of relatively high sulphur content often contaminates the water coming in contact with it. If this occurs, the water becomes a solution of weak sulphurous acid or contains other toxic elements. As a general rule, strip pits near the bottom of hills contain less toxic water and offer better chances of success with fish than those on the higher slopes.

CHANGES OF VEGETATION

Immediately after being formed, spoil banks are bare of vegetation. The physical conditions previously discussed affect the rate with which spoil banks are revegetated naturally. In general, spoil banks become covered with natural vegetation very slowly because of poor seedbed conditions on their surface. Woody plants generally begin to invade spoil banks within three years. A thin cover of herbaceous plants may also develop along with the pioneer trees and shrubs, but generally it is about twenty years before a tree cover occurs naturally.

As a consequence of the slow rate of natural revegetation, many states require that coal operators revegetate the barren spoils. By carefully selecting the species and sites, tree plantings have been made with a survival rate of more than sixty percent.[19] Physical benefits derived from reforesting spoil banks include reduction of erosion, addition of organic matter to the spoil, and lowering the rate of moisture evaporation.

Contrary to popular opinion, grading the spoil banks does not aid plant growth. Rather, a poorer growth of trees on graded strip-mined lands is caused by poor aeration and moisture conditions due to the compaction from the weight of grading machinery. Surfaces have been reported to be compacted to depths of two feet as a result of the use of heavy machinery.[20] Graded banks dry more rapidly during periods of drouth than ungraded because graded banks cannot absorb what little rain falls. On the other hand, when there is heavy rainfall graded banks tend to become waterlogged because of a lower percolation rate.

EXTENT OF STRIP COAL MINING

It is difficult, perhaps impossible, to ascertain the exact number of acres which have been strip mined in the United States. The problem is made difficult because accurate records of acres stripped are rarely kept. The principal interest lies in the amount of coal produced, rather than the area stripped. By inductive reasoning, however, it is possible to arrive at a reasonable estimate.

For example, the total amount of strip-mined coal from 1914 through 1954 was approximately 1,905,710,000 tons.[21] This means that an area of about 380,000–

[19] This is an average for the state of Indiana, but it varies with proximity to seed sources, texture and fertility of spoil banks, and availability of moisture.

[20] A. Limstrom, "Effects of Grading Strip-Mined Lands on the Early Survival and Growth of Planted Trees," *Central States Forest Experiment Station, Technical Paper No. 130*, pp. 1–32.

[21] Data from 1914 to 1949 from *Minerals Yearbook, 1950*, pp. 284–285; estimates used for the years 1950–54.

400,000 acres has been stripped for coal in the United States since 1941.[22] At present the strip-mined area is increasing at the rate of about 20,000 acres per year. Undoubtedly this rate will increase, since the percentage of coal mined by stripping methods is showing a steady rise.

Since levelling of spoil banks is negligible in most areas and weathering and erosion of stripped areas is slow by human standards (although rapid when considered from a geomorphological standpoint) the spoil heaps will become even more apparent features of the landscape. Similarly thousands of acres of land which have been undercut by underground mining will begin to feel the effects of subsidence after props begin to rot out of abandoned mines.

CONCLUSIONS

Man's removal of coal for fuel has resulted in a change in the physical landscape. By underground mining man causes accumulations of rock debris near the mine mouth which form longitudinal or conical hillocks. Earthquake-like tremors due to subsidence frequently occur. Man-induced faulting results in temporarily deranged drainage patterns, occasional depressions, and other surface modifications. Where underground fires have begun in coal seams near the surface, fumarole-like features are occasionally seen. Many other subtle chemical and physical changes affecting the rate of weathering also occur due to underground mining, but it is difficult to ascertain their significance or extent quantitatively.

By strip mining man makes an even more obvious imprint upon the landscape. Modified ridge-valley terrain is developed, soil profiles are disturbed, buried rock strata are exposed to surface weathering, lakes are formed, and the spoils are made barren of vegetation.

Continued heavy fuel demands in the United States will result in more widespread influence of man upon terrain. Coal mining is but one of many examples of man's role as a geomorphological agent.

[22] Figure determined by dividing the total amount of coal mined by stripping since 1914 by 5000 tons. Technicians at the Central Forest Experiment Station at Columbus, Ohio, estimate that 4000–6000 tons of coal are mined from each stripped acre.

THE NATURE AND ORIGIN OF THE CANADIAN DRY BELT*

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PALLISER'S Triangle, a large dry area in southern Alberta, Saskatchewan, and Manitoba, extending northward from the United States border approximately to latitude 52°N. and westward from longitude 100°W. to 114°W., has been a regional geographic reference since Captain John Palliser[1] explored the vast unsettled interior of southern Canada nearly a century ago. Recognition of the distinctively dry character of this part of Canada is found in Palliser's reports made as a result of field work in 1857, 1858, 1859, and 1860.[2] Although Palliser's contemporaries varied in their opinions of his conclusions regarding the usability of the land for agricultural settlement,[3] opinion based upon climatological observations has been unanimous in its indictment of the area. Fifty years ago Stupart noted significant regionalisms in terms of temperature and precipitation characteristics in western Canada,[4] and later Connor, in the most painstaking research on Canadian climate, pointed to the problem nature of the "Dry Belt," as he called it, refining somewhat Palliser's conclusions concerning the extent of abnormally dry conditions.[5]

Since Connor's study of Canadian climate was made, a great body of surface

* The author expresses his sincere appreciation for assistance in the preparation of this study to Professor Glenn T. Trewartha of the Department of Geography at the University of Wisconsin and to Dr. Charles F. Brooks, Director, Blue Hill Meteorological Observatory, Milton, Massachusetts.

[1] John Palliser, *Papers Relative to the Exploration by Captain Palliser of that Portion of British North America which lies Between the Northern Branch of the River Saskatchewan and the Frontier of the United States; and Between the Red River and the Rocky Mountains* (London: Eyre and Spottiswoode, 1859), and John Palliser, *Exploration—British North America. Further Papers Relative to the Exploration by the Expedition under Captain Palliser of that Portion of British North America which lies between the Northern Branch of the River Saskatchewan and the Frontier of the United States; and Between the Red River and the Rocky Mountains, and thence to the Pacific Ocean* (London: Eyre and Spottiswoode, 1860).

[2] John Palliser, *Exploration—British North America. The Journals, Detailed Reports, and Observations Relative to the Exploration, by Captain Palliser, of that Portion of British North America, which, in Latitude, lies Between the British Boundary Line and the Height of Land or Watershed of the Northern or Frozen Ocean Respectively, and in Longitude, Between the Western Shore of Lake Superior and the Pacific Ocean during the Years 1857, 1858, 1859, and 1860* (London: Eyre and Spottiswoode, 1863).

[3] Henry Youle Hind, "On the Commercial Progress and Resources of Central British America. The Lake Winnipeg and Saskatchewan Districts," *Journal of the Statistical Society of London*, Vol. 27 (1864), pp. 82–105; and John Macoun, *Manitoba and the Great Northwest* (London: Thomas C. Jack, 1883), pp. 142–154.

[4] R. F. Stupart, "The Canadian Climate," *Report of the 8th International Geographic Congress, 1904* (U. S. Government Printing Office, 1905), pp. 296–300.

[5] A. J. Connor, "The Climates of North America. Canada," in W. Köppen and R. Geiger, *Handbuch der Klimatologie*, Bd. II (Berlin, 1938), Teil J, pp. 359–364.

meteorological data has accumulated on the Dry Belt; and to this information has been added the beginning of significant upper-air information particularly in the form of "normal" charts of pressure distribution at various levels above the surface of the earth.[6] It is the purpose of this paper to examine the recent data to define more exactly the extent of the Dry Belt in terms of its major uniquenesses and to determine, as far as data will allow, the causes for the distinctive climatic regionalism of the Dry Belt.

The distribution of stations whose climatological records are used in this study is shown in Figure 1. A serious attempt was made to abide by Conrad's general

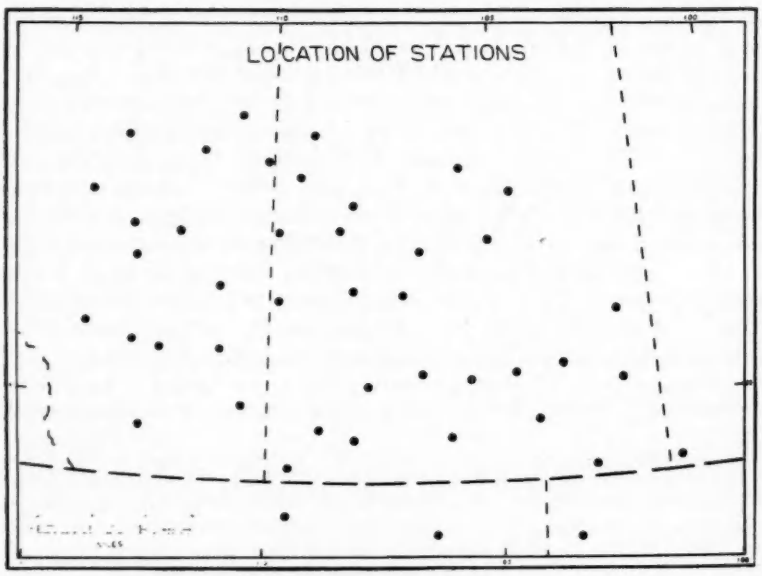


FIG. 1. Location of stations.

conclusion that "from all points of view, the length of normal period should be about 25 to 35 years."[7] Whenever this rule was violated it was because it was deemed wiser to include a station with a somewhat shorter record to make the climatological network more complete rather than to leave a significant part of the network void.

REGIONALIZING FEATURES OF PRECIPITATION

Moisture characteristics form the primary basis for the contention that the Dry Belt is a unique and distinctive climatic region. Figure 2 shows the areal extent of the Dry Belt as defined by this study in comparison with Palliser's Triangle; this comparison indicates that the Dry Belt is approximately one-half the size of Pal-

[6] See list of surface and upper air data sources at end of report.

[7] Victor Conrad, *Methods in Climatology* (Harvard University Press, 1944), p. 148.

liser's Triangle, overlapping most of the northern part of the region marked off by Captain Palliser as unfit for human settlement, and extending at least 100 miles beyond the northern limit of the Triangle. In total area the Dry Belt measures approximately 50,000 square miles, nearly equal to the size of Alabama or Greece.

The Canadian Dry Belt is the largest of several dry regions in the Great Plains of North America. Others, located in Montana, South Dakota, and Wyoming,[8] are not so marked by the frequency of stations reporting less than twelve inches of precipitation per year. Figure 3 on average annual precipitation clearly marks the Dry Belt as a region of little precipitation, having an elliptical shape, and trending in

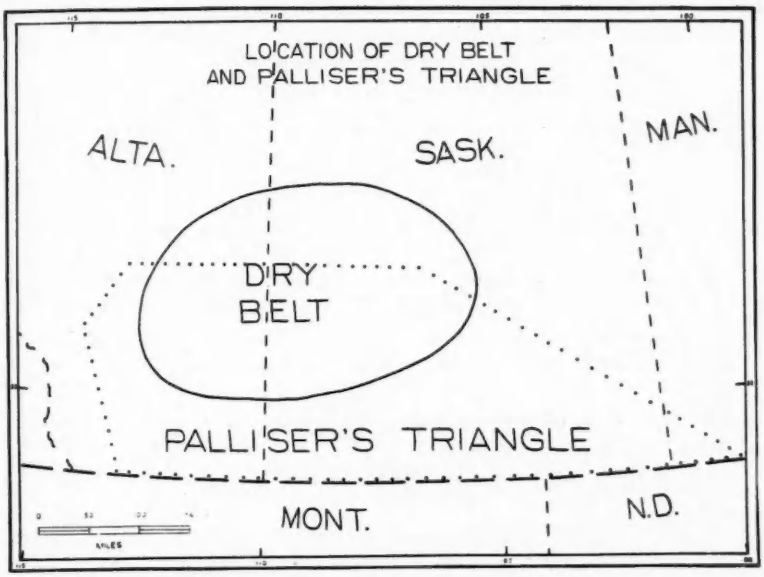


FIG. 2. Location of Dry Belt (continuous line) and Palliser's Triangle (dotted line) in southern Canada.

a west-east direction 150 miles north of the Canadian border. A broader view of the Dry Belt in North America (Figs. 4 and 5) shows that it occupies low points along two precipitation profiles, one of which traverses North America from west to east along latitude 51°N., and the other parallels the east face of the Rocky Mountains from latitude 25°N. to latitude 60°N., but is located at a uniform distance of 250 miles east of the front of the Rockies (corresponding to the distance from the core of the Dry Belt to the Rockies). The slight increase in maximum precipitation immediately south of the Dry Belt (Fig. 5) reflects the localized effect of the Cypress Hills. Measurement of the rate of precipitation change per 100 miles of horizontal

[8] *Climate and Man*, Yearbook of Agriculture (U. S. Dept. of Agriculture, 1941), pp. 965, 1117, 1209.

distance (Fig. 6) reveals that the climatic boundary of the Dry Belt is most marked to the west, approximately equally marked to the north and east, and least marked to the south. The southern limit of the Dry Belt is better marked when certain other climatic features are examined.

When annual precipitation curves representative of the Dry Belt and its surroundings are studied, significant differentiating factors are added to the factor of total annual precipitation. Anglia, Saskatchewan, Edmonton, Alberta, Williston, North Dakota, and Winnipeg, Manitoba (Figs. 7–10) represent conditions typical, respectively, of the Dry Belt and areas to the north, south, and east. Such compari-

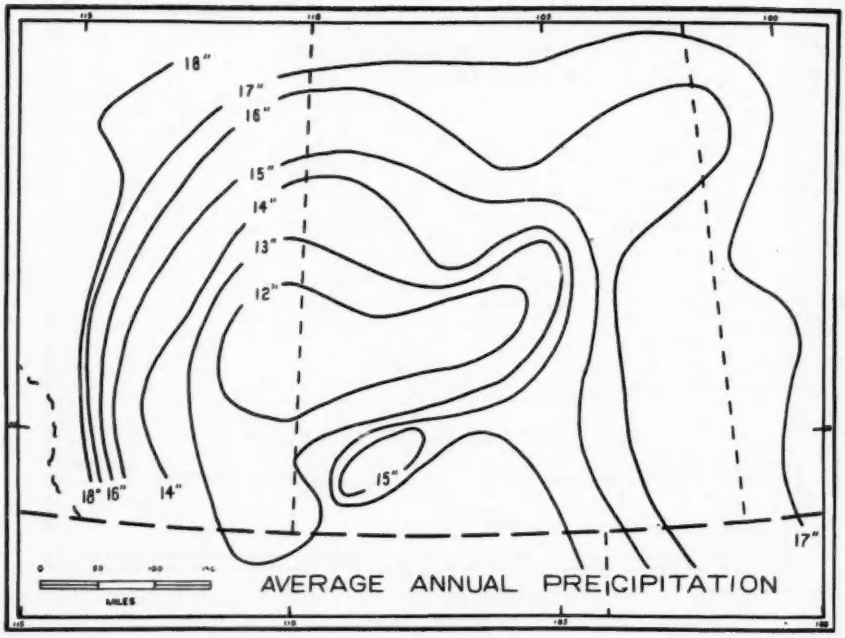


FIG. 3. Average annual precipitation.

son shows: (1) The Dry Belt's wettest months are distinctly drier than its surroundings—adjacent precipitation curves record two months each with more than 3 inches, but the Dry Belt's wettest month, June, has only 2.4 inches. (2) The wettest months in the Dry Belt are the warmest months, lessening the total effectiveness of the "wet season," but to the south—Williston, North Dakota—the "wet season" comes slightly earlier, May-July, at a time when the precipitation may be more effectively utilized. (3) Although the Dry Belt has a distinct secondary midwinter maximum of precipitation, a regionalizing feature lacking to the south and east (Fig. 7), it is not sufficiently large to be significant; moreover, as will be shown, chinooks here tend to nullify the fall of precipitation during the winter.

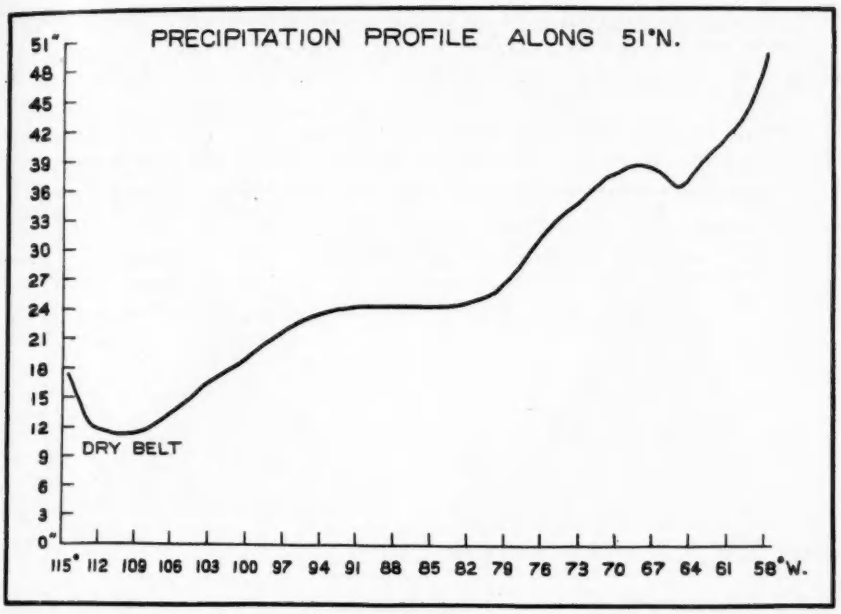


FIG. 4. Precipitation profile along latitude 51°N. from the Rocky Mountains to the Atlantic Ocean.

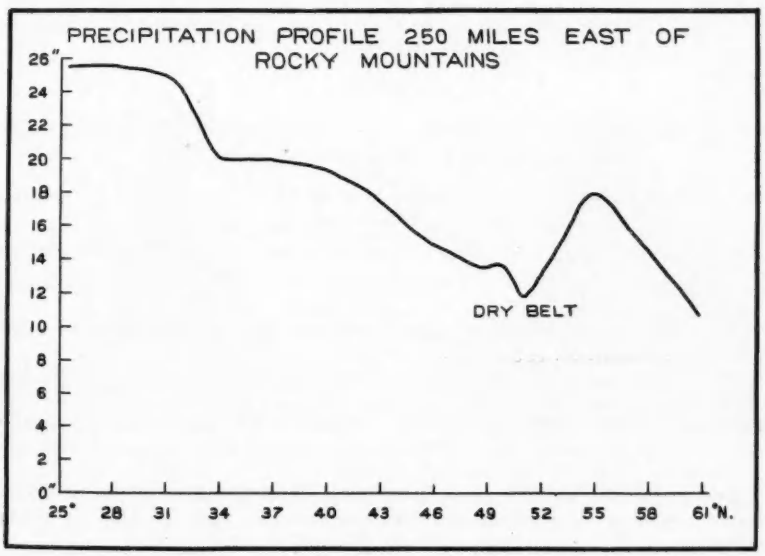


FIG. 5. Precipitation profile 250 miles east of the Rocky Mountains.

Variability of precipitation is an unfailing companion to dry regions and is marked in the Dry Belt in a number of ways. Both Currie[9] and Longley[10] have given statistical proof of the high variability of precipitation from year to year in the Dry Belt, and Connor's[11] study has taken note of the unusually dry conditions here during the drier cycles which characterize the Dry Belt. Studies by the writer have shown that the Dry Belt is specifically marked by fewer days with precipitation

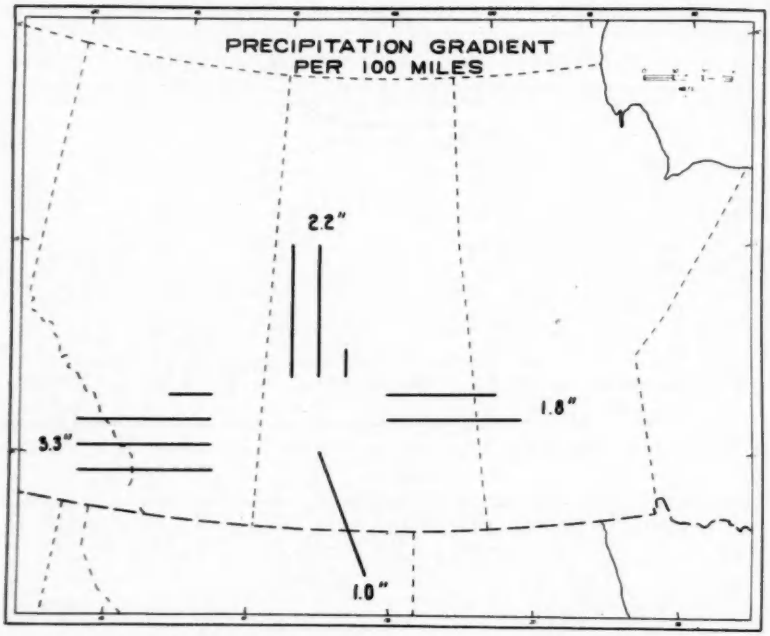


FIG. 6. Precipitation gradient per 100 miles from the center of the Dry Belt.

during both unusually dry years and unusually wet years, as well as a lower precipitation intensity during both abnormally dry and moist years.[12]

The longest period with less than 0.25 inches of precipitation[13] during the April-

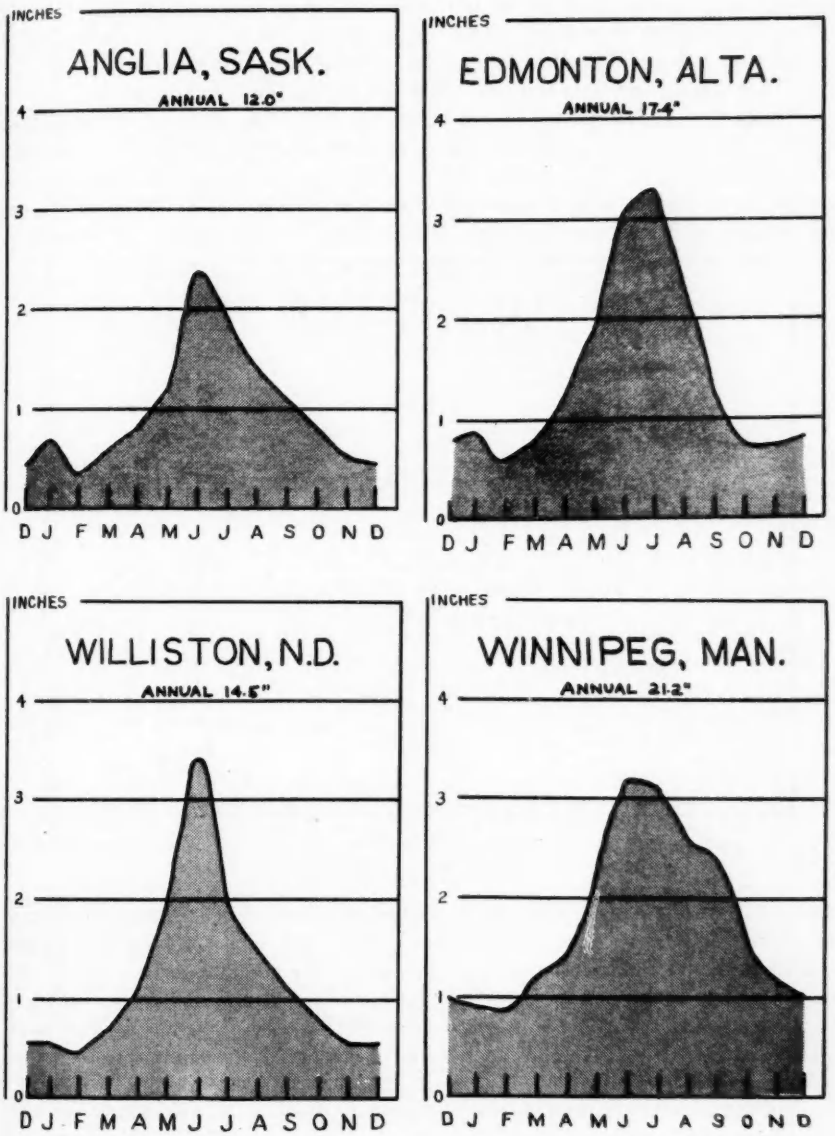
[9] B. W. Currie, *Prairie Provinces and Northwest Territories: Precipitation* (Saskatoon: University of Saskatchewan, 1953), pp. 10–12 and Table I.

[10] Richard W. Longley, "Variability of Annual Precipitation in Canada," *Monthly Weather Review*, Vol. 81 (1953), pp. 131–134.

[11] A. J. Connor, "Droughts in Western Canada," *The Canada Year Book* (Dominion Bureau of Statistics, 1933), pp. 47–59.

[12] The abnormally dry years included 1936, 1945, and 1949; the abnormally wet years were 1942, 1946, and 1947. During each of these six years the period of most noticeable regional pattern in the Dry Belt was April through August.

[13] Conrad considers 0.25 inches of precipitation the minimum necessary to break a drought. See Victor Conrad and L. W. Pollak, *Methods in Climatology* (2nd ed.; Harvard University Press, 1950), p. 213.



FIGS. 7–10. Precipitation profiles for Anglia, Sask., Edmonton, Alta., Williston, N. D., and Winnipeg, Man.

through-August span of major dry years shows as clearly as any measure the seriousness of the drought problem in the Dry Belt (Fig. 11). Most of the Dry Belt had at least two months without significant precipitation, and the eastern half was "dry" for two and one-half months—all of this during the normally wet season!

Application of the principles and criteria contained in the new Thornthwaite (1948) classification of climate[14] allows mathematical integration of the several factors which combine to produce the world climates. Although the Thornthwaite system is not unique in this respect, it does succeed where other climatic systems fail, viz., in differentiating the Dry Belt from its surroundings.[15] A large area

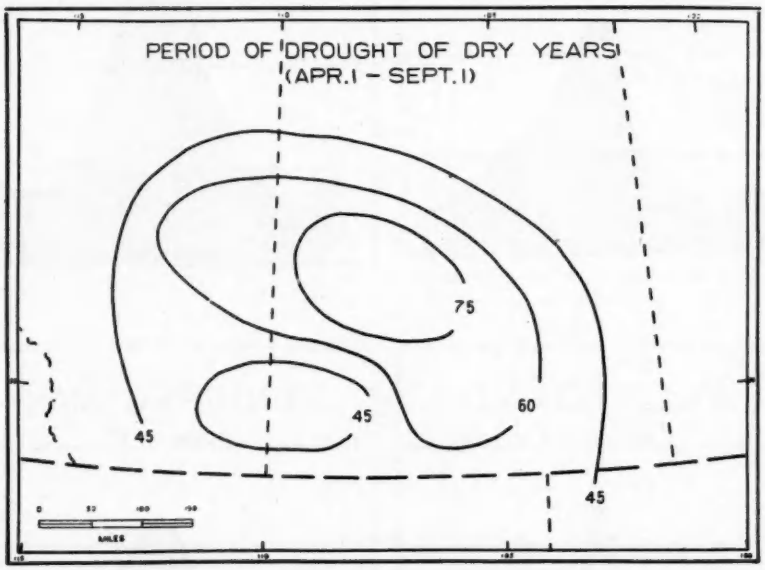


FIG. 11. Period of drought—the longest period with less than 0.25" of precipitation—during the wet season of major dry years (1936, 1945, 1949).

north of the United States–Canada border and lying astride the Alberta–Saskatchewan border in the Dry Belt has a moisture index of less than – 25 (Fig. 12). Since – 20 marks the boundary between C_1 (the driest of the humid climates) and D (the moistest of the dry climates), it is apparent that the sector within the isoline of – 25 is an intensification of the generally dry conditions east of the Rocky Mountains. This isoline encloses the southern two-thirds of the area of this study and is oriented west-east at latitude 51°N.

For the normally wettest month of the year—June—this area stands out with

[14] C. W. Thornthwaite, "An Approach Toward a Rational Classification of Climate," *Geographical Review*, Vol. 38 (January 1948), pp. 55–94.

[15] Marie Sanderson, "Drought in the Canadian Northwest," *Geographical Review*, Vol. 38 (1948), pp. 289–299.

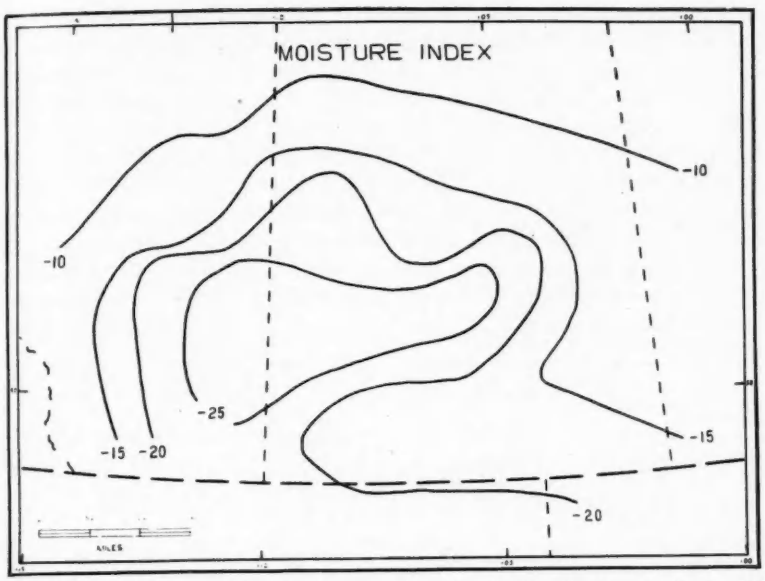


FIG. 12. Moisture index according to the new Thornthwaite classification of climate (1948).

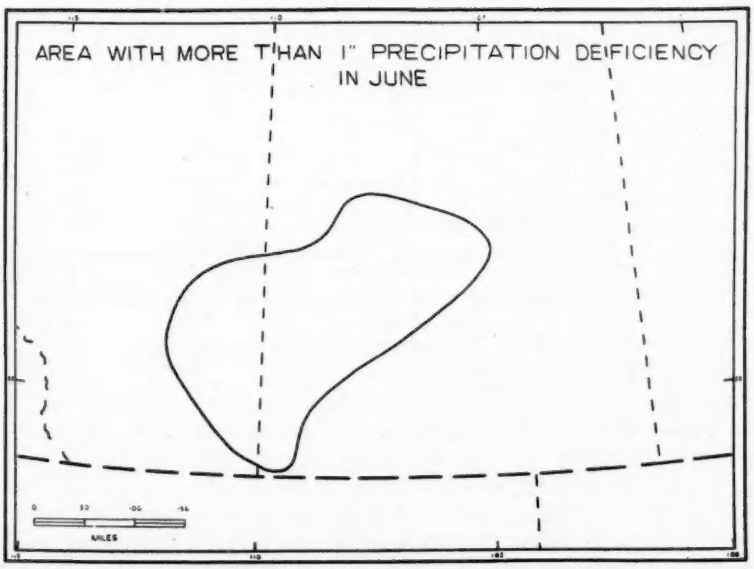


FIG. 13. Area with more than 1" precipitation deficiency in June, according to the new Thornthwaite classification of climate (1948).

a marked deficiency of moisture, according to the Thornthwaite system (Fig. 13). Within the Dry Belt the following deficiencies of precipitation with respect to potential evapotranspiration occur: Medicine Hat, Alta., 1.8″; Wastina, Alta., 1.5″; Anglia, Sask., 1.7″; Outlook, Sask., 1.9″. Very little or no deficiency during that month occurs in all directions from the Dry Belt: Calgary, Alta., 0.0″; Edmonton, Alta., 0.0″; St. Walburg, Sask., 0.0″; Prince Albert, Sask., 0.0″; Indian Head, Sask., 0.0″; Havre, Mont., 0.4″; Williston, N.D., 0.0″. Much of the Dry Belt thus is characterized by distinctly greater actual deficiencies of precipitation during the wettest month of the year than is true of all areas around it. The magnitude of the June maximum in the precipitation curve typical of the Dry Belt (i.e., Anglia, Sask.) emphasizes its importance to the total moisture picture here; the Thornthwaite

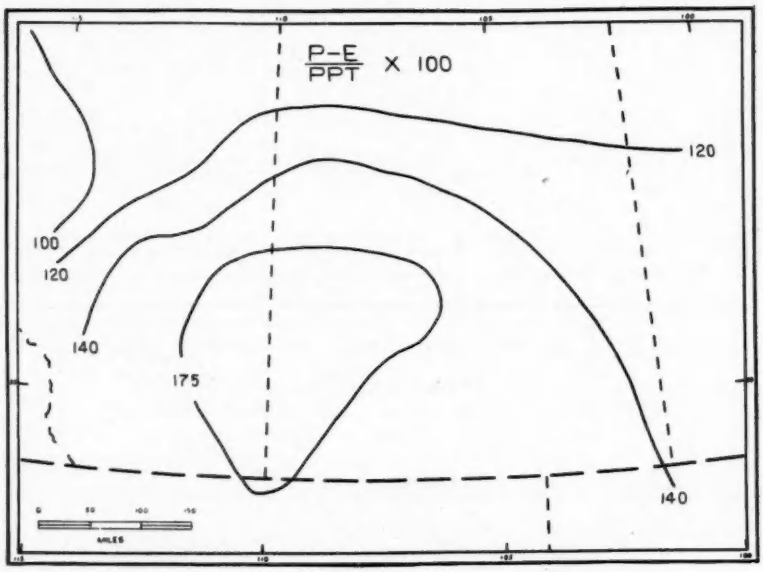
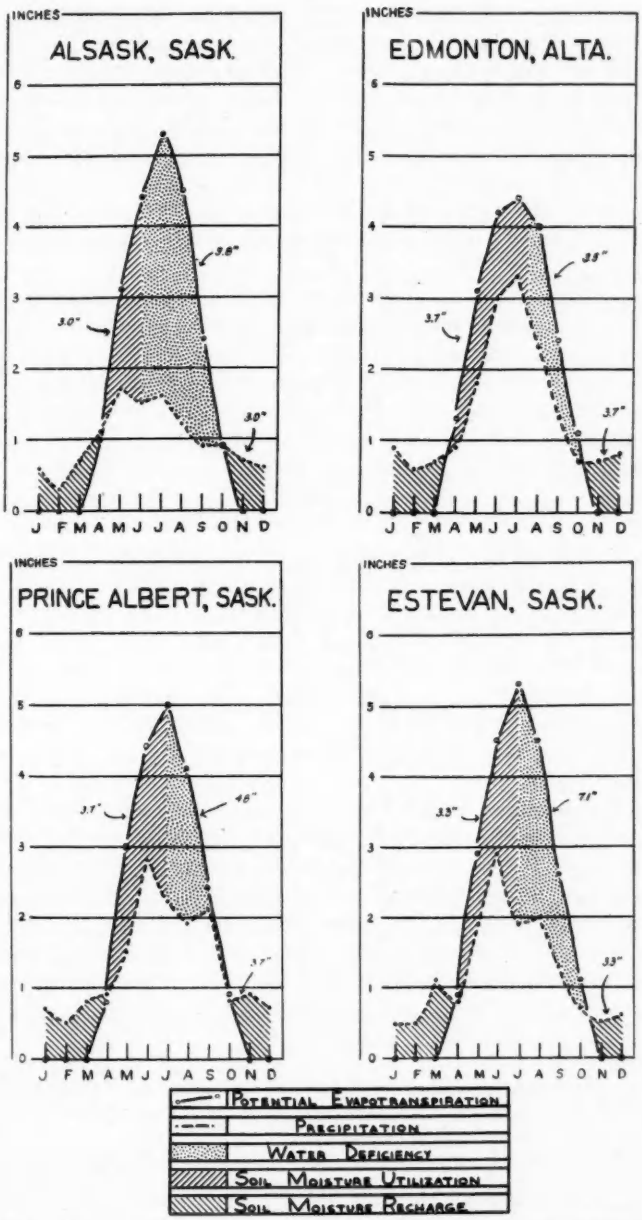


FIG. 14. Ratio of potential evapotranspiration to annual precipitation multiplied by 100.

classification reveals that even this strong June maximum is not sufficiently great to overcome normal evaporation.

Almost the same pattern as in the previous instance is produced when the ratio of potential evapotranspiration to annual precipitation is mapped. In a large area of southern Alberta and Saskatchewan, including much of the Dry Belt, the potential evapotranspiration is more than 175 percent of the annual precipitation (Fig. 14).

The graphs of potential evapotranspiraion and annual precipitation for a number of stations in and about the Dry Belt reveal significant patterns (Figs. 15, 16, 17, and 18). The Dry Belt station, Alsask, Sask., has a high water deficiency (9.8 inches), which extends over four months (June–September), and a relatively meager



FIGS. 15–18. Graphs of potential evapotranspiration and precipitation for Alsask, Sask., Edmonton, Alta., Prince Albert, Sask., and Estevan, Sask.

soil moisture recharge (3.0 inches). To the northwest, Edmonton, Alta., has a considerably lower water deficiency (3.5 inches), which also becomes marked somewhat later in summer than to the southeast, and a larger soil moisture recharge (3.7 inches) than Alsask. The pattern to the northeast as evidenced by Prince Albert is very similar in terms of water deficiency and soil moisture recharge (4.8 inches and 3.7 inches, respectively). Estevan, Sask., southeast of the Dry Belt, is characterized by a lower water deficiency (7.1 inches) and higher soil moisture recharge (3.3 inches) than the Dry Belt station. Moreover, water deficiency does not become apparent until a month later in summer, although it persists somewhat later in autumn.

The new Thornthwaite classification of climate aids significantly in differentiating the Dry Belt from its surroundings in Canada. The moisture isoline of −25 (Fig. 12) coincides fairly well with other more direct climatic measures in use to define climatic regions. The Dry Belt has a markedly greater deficiency of moisture per year and a lesser soil moisture recharge than shown by graphs for individual stations outside the Belt. Finally, the wettest month of the year in the Dry Belt, June, has a considerably greater moisture deficit than is true elsewhere.

DISTINCTIVE FEATURES OF TEMPERATURE

During the summers of abnormally dry years (1936, 1945, 1949) the average temperature departure ranges well above the long-time average (Fig. 19). According to a recent study the average summer interannual variability of temperature in the vicinity of the Dry Belt is about 2.5°F.;[16] hence temperature departures of +4.0°F. in the Dry Belt during very dry years serve to emphasize the abnormally high evaporating temperatures of these periods. Excessive heat constantly evaporating moisture away from the surface of the earth added to the below-normal return of moisture in the form of precipitation marks the Dry Belt as a region of double misfortune.

Nearly fifty years ago Stupart[17] noted several unusual winter temperature characteristics of the part of Alberta lying east of the foothills of the Rocky Mountains: (1) the area experienced rapid changes of temperature which, in winter, occurred in extremely short periods of time, (2) southern Alberta had milder winters than the land to the east, and (3) there was marked variability in mean winter temperature from year to year. Koeppe[18] and Connor[19] noted much the same picture. Exceptionally rapid changes in temperature in extremely short periods of time[20] along

[16] B. W. Currie, *Prairie Provinces and Northwest Territories: Temperature* (Saskatoon: University of Saskatchewan, 1953), Table 7.

[17] Stupart, *op. cit.*, p. 298.

[18] Clarence Eugene Koeppe, *The Canadian Climate* (Bloomington: McKnight and McKnight, 1931), pp. 117–118.

[19] Connor in Köppen and Geiger, *op. cit.*, p. 361.

[20] Actually the winter temperature gradient across the Dry Belt (4.2°F/70 miles) is nearly twice as great as the very steep winter gradient in eastern U. S. See Glenn T. Trewartha, *An Introduction to Climate* (3d ed.; New York, 1954), p. 328.

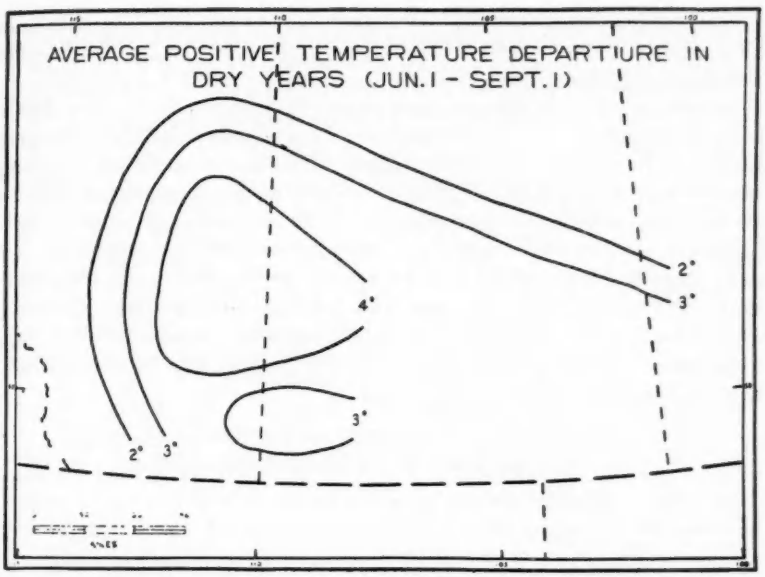


FIG. 19. Average positive temperature departure during summers of abnormally dry years—1936, 1945, 1949.

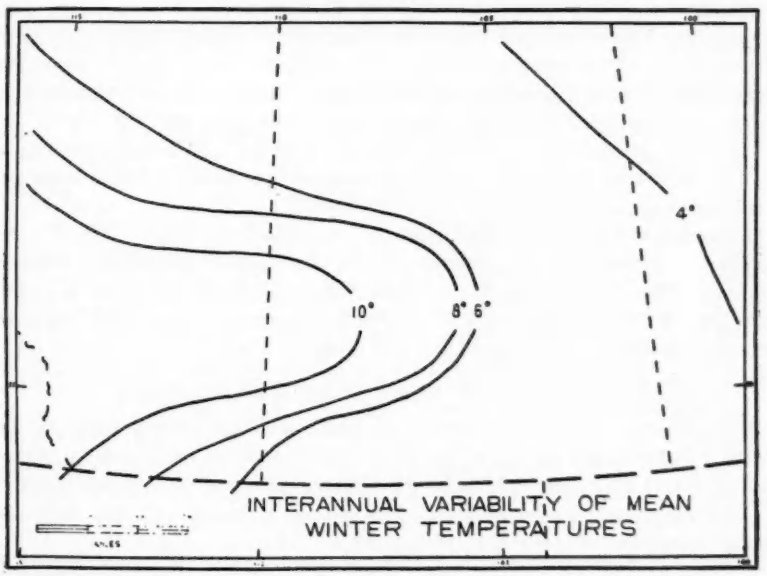


FIG. 20. Interannual variability of mean winter temperatures, 1930–1949 incl.

with comparative mildness of winters have led Thomson and Connor[21] to assert that the chinook, or "snow eater," finds its best expression on the North American land mass in southern Alberta.

The interannual variability of mean winter temperature in the Dry Belt (Fig. 20) is well marked—averaging over 8.0°F. These statistics indicate a temperature oscillation of three times the average interannual summer variation. Indeed, the pattern of high interannual variability of mean winter temperature comes close to an accurate cartographic representation of frequent chinook activity; for it is the chinook, with its abnormal winter warmth penetrating eastward for a short distance onto the Plains, which causes winter temperatures to exceed the long-time normal. During those winters when cold polar air from northern Canada holds sway westward to the foot of the Rockies, the pendulum swings the other way, and bitterly cold weather dominates the entire Dry Belt as well as much of the vast interior of North America.

EXPLANATIONS FOR THE EXISTENCE OF THE DRY BELT

CYCLONIC AND ANTICYCLONIC FREQUENCY

The presence of moist air masses, either at the surface or aloft, is prerequisite to the production of precipitation in a region but does not insure that precipitation. In all cases sufficient lifting of relatively moist air must precede the release of the water content of the air mass. Lifting of air masses can be measured by an enumeration of cyclonic passages. Figure 21, showing the average summer frequency of cyclonic passages near the Dry Belt over the period 1930–49 inclusive, indicates that the Dry Belt is normally a region of infrequent cyclonic action. In northern Alberta lies a heavily traveled track, and to the south, the important North Pacific track. The Dry Belt is frequented by approximately one-half as many cyclonic passages during the summer as areas to the north (compare Figs. 21, 7, and 8) and to the immediate south (compare Figs. 21, 7, and 9). These comparisons point out the apparent relationship between summer precipitation and frequency of cyclonic passages.

A similar enumeration of frequency of anticyclonic passages (Fig. 22) reveals a higher frequency of such occurrences in a northwest-southeast line through the Dry Belt. The effect of relatively greater dominance of subsiding air is seen when the relatively dry "wet season" in the Dry Belt is compared with the "wet season" of its surroundings (compare Fig. 7 with Figs. 8, 9, and 10).

LOCATION RELATIVE TO MOIST AIR MASS TRAJECTORIES

In a statistical analysis of surface air mass flow over North America, Brunnschweiler[22] discovered that polar maritime (*mP*) air from the Pacific source region moves onto North America during the summer in a peculiar two-pronged surge.

[21] Andrew Thomson and A. J. Connor, *The Climate of Canada* (Toronto: Meteorological Division, Department of Transport, 1949), p. 13.

[22] Dieter H. Brunnschweiler, "The Geographic Distribution of Air Masses in North America," *Geographische Mitteilungen*, Jahrg. 97 (1952), p. 46.

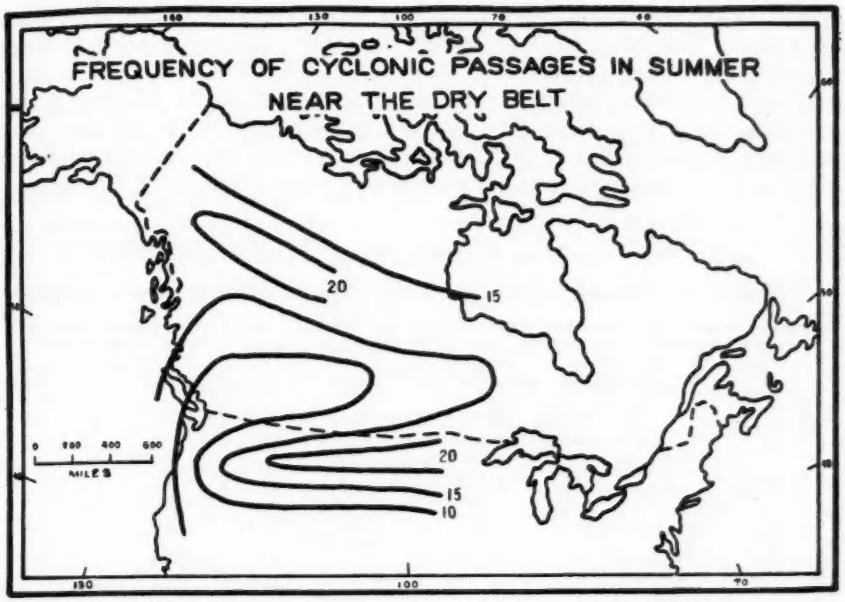


FIG. 21. Frequency of cyclonic passages near the Dry Belt, 1930–1949 incl.

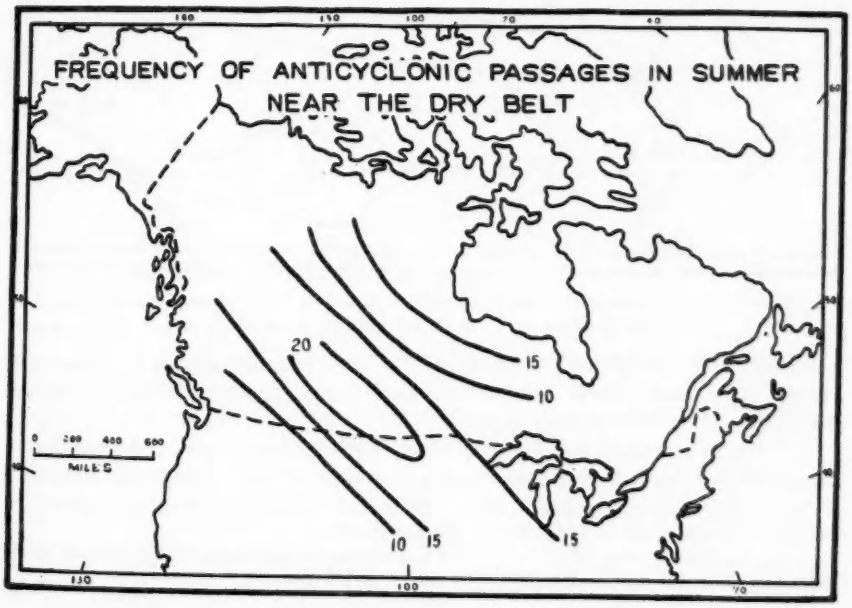


FIG. 22. Frequency of anticyclonic passages near the Dry Belt, 1930–1949 incl.

One prong moves southward along the Pacific coast of the United States to southern California. The other crosses the Rocky Mountains and moves southward along the east side of these mountains to the position of the Dry Belt where a sharp gradient occurs in the frequency of *mP* air. This distinctly higher frequency of *mP* air during the summer north of the Dry Belt would help to explain the very sharp maximum of precipitation at 55°N. (Fig. 5); conversely, the Dry Belt minimum must, in part, owe its being to the considerably lower frequency of *mP* air here than to the north.

MAJOR JET STREAM LOCATION IN NORTH AMERICA DURING JULY

Figure 23 shows the strength and average position of the jet stream for July,[23]

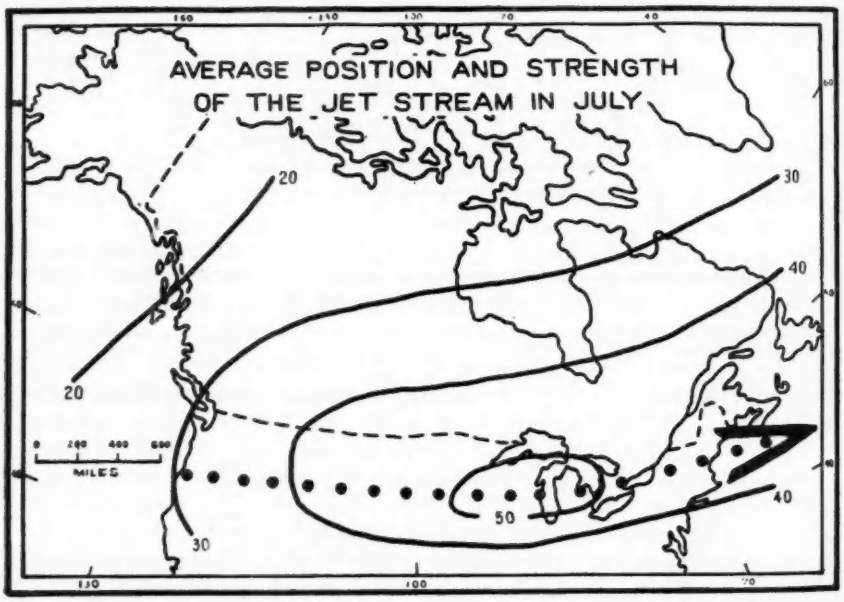


FIG. 23. Average position and strength of the jet stream in July; values of geostrophic wind speed in miles per hour at the level of maximum speed.

a location near the northern boundary of the United States typical of summer conditions in North America. Numbers indicate geostrophic wind speed in miles per hour at the level of maximum speed.

Rossby indicated a probable relationship between jet streams and precipitation distribution;[24] later, Starrett discovered "when allowance is made for latitudinal

[23] Jerome Namias and Philip F. Clapp, "Confluence Theory of the High Tropospheric Jet Stream," *Journal of Meteorology*, Vol. 6 (1949), pp. 330–336.

[24] C. G. Rossby *et al.*, "On the General Circulation of the Atmosphere," *Bulletin of the American Meteorological Society*, Vol. 28 (1947), pp. 255–280.

variations in the availability of moisture . . . the precipitation tends to be a maximum underneath the jet."[25] However, even in locations where conditions seemed favorable for precipitation, the latter study found 19 percent of the jet streams to be "dry." The Dry Belt's position north of the jet stream means it is in an area of inflow along the left side of the jet. This inflow leads to subsidence aloft, which is probably associated with the decrease in precipitation during summer north of the jet stream to about lat. 51°N. (Fig. 5). That there is no peak in the precipitation profile (Fig. 5) beneath the jet seems reasonable on the basis of the position of the

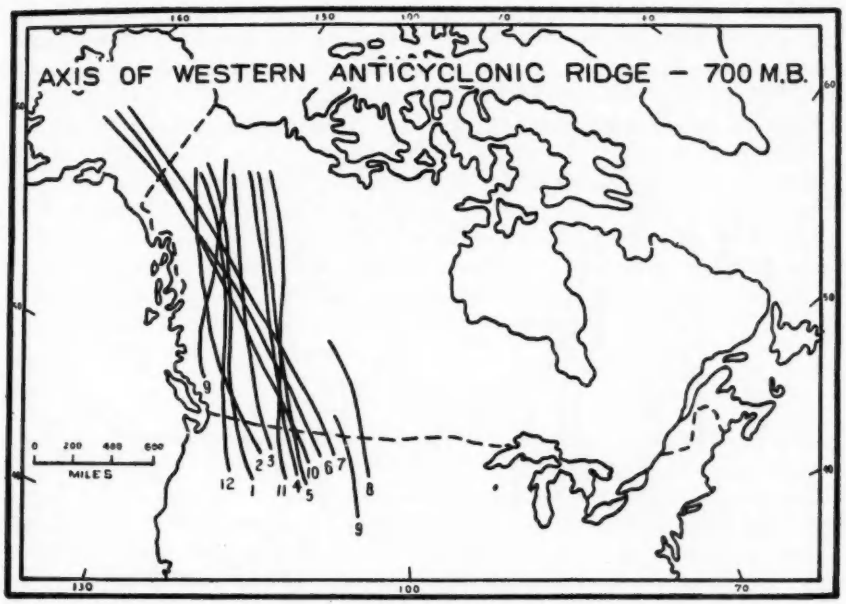


FIG. 24. Axis of western anticyclonic ridge at 700 mb. height.

jet with respect to the major source of moisture, viz., the Atlantic Ocean or Gulf of Mexico and the average trajectory of the tropical maritime air masses over North America.[26]

Although reaching no maximum beneath the jet, precipitation does increase south of the Dry Belt in the direction of the mean summer position of the jet stream (Fig. 5). Moreover, the area to the south of the Dry Belt lies in the path of the important North Pacific low track (Fig. 21). Riehl's conclusions clearly apply to this moister area to the south: "When jet stream . . . and low tropospheric dis-

[25] Lloyd G. Starrett, "The Relation of Precipitation Patterns in North America to Certain Types of Jet Streams at the 300-Millibar Level," *Journal of Meteorology*, Vol. 6 (1949), p. 347.

[26] For a summary report on the influence of the jet on surface climates see H. Riehl *et al.*, *The Jet Stream*, Meteorological Monographs, Vol. 2, No. 7 (1954), pp. 34–37.

turbance coincide in a favorable sense, ensuing cyclone developments will attain the greatest intensity."[27]

UPPER AIR PRESSURE DISTRIBUTION

Surface pressure charts indicate a probable relationship between low frequency of cyclones and high frequency of anticyclones with the low precipitation of the Dry Belt. Upper air distribution reveals still further evidence of the subsidence and divergence of air over the Dry Belt. The anticyclonic ridge plotted at a height of 700 mb. (Fig. 24) is located over the Dry Belt from June through September, a period of considerably less precipitation in the Dry Belt than in its surroundings.

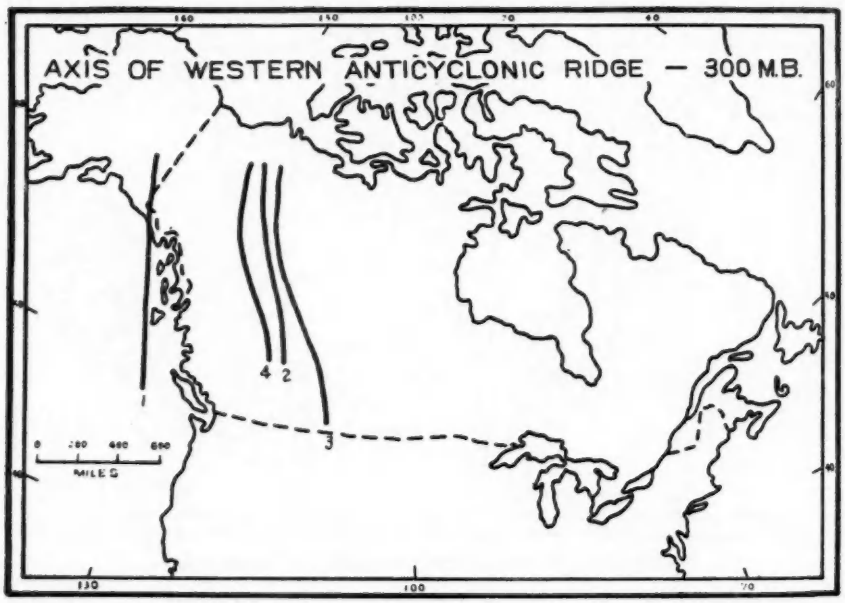


FIG. 25. Axis of western anticyclonic ridge at 300 mb. height.

Charts of air pressure distribution at a height of 300 mb. show a ridge over the Dry Belt (Fig. 25) during July, indicating subsidence and divergence of considerable depth in the atmosphere.

WESTERLY AIR FLOW OVER THE ROCKY MOUNTAINS

The effect of a large highland barrier on westerly air flow is a subject of considerable interest. Bolin notes that "the only mountains which may be of real importance in generating planetary waves in the westerlies are the Rocky Mountains

[27] Herbert Riehl, "Jet Stream in Upper Troposphere and Cyclone Formation," *Transactions*, American Geophysical Union, Vol. 29 (1948), p. 186.

and the mountains in the interior of Asia."[28] In a study which bears significance to the Dry Belt, Wexler[29] discusses perturbations in the westerlies which result in the formation of two anticyclonic cells leeward of the Rocky Mountains. The first of these anticyclonic cells, centered in the southern Great Plains, is composed of vast moist and dry currents winding about the cell and affecting the surface weather. A normal summer isentropic chart, originally prepared by Namias,[30] is used by Wexler to illustrate certain relationships between the anticyclonic development and precipitation patterns. This chart indicates a dry current of air directly over the Dry Belt, moving eastward along the northern edge of the large anticyclonic cell. Thus the deformation which westerly air flow undergoes as a result of being forced over the highland barrier of western North America results in the development of an anticyclonic flow curvature attended by a dry current of air over the Dry Belt.

Borchert has shown by means of streamlines of resultant mean air flow at the gradient level that the dry continental air flow—or flow directly from the mountains as opposed to flow from the tropical Atlantic—is confined in July to the area bounded by the Alberta storm track, the 100th meridian, and the United States border.[31] Thus the Dry Belt has stronger mean westerlies than other parts of the Great Plains in summer; these westerlies diverging from a northerly flow along the Pacific coast undergo a chinook effect east of the highland barrier during the *summer* as well as during the winter. In a later study Borchert has demonstrated the dominance of Dry Continental surface wind flow in this area.[32]

HORIZONTAL DIVERGENCE

Wind observations lend themselves to another technique by which the Dry Belt may be differentiated from its surroundings in order to explain its unique regional character. The triangular volume method for determining horizontal divergence allows direct computation of horizontal divergence from wind observations.[33] Resultant wind flow for the period April to September was computed, and the partial horizontal divergence for three sets of triangulation stations was determined. The three triangles used in this analysis are plotted on Figure 26. The results are given in the table below, in which negative values correspond to convergence and positive values to divergence.

These calculations clearly indicate that the Dry Belt stands apart from its sur-

[28] B. Bolin, "On the Influence of the Earth's Orography on the General Character of the Westerlies," *Tellus*, Vol. 3 (1950), p. 192.

[29] Harry Wexler, *Some Aspects of Dynamic Anticyclogenesis*, University of Chicago Publications in Meteorology, No. 8 (1943), p. 26.

[30] Jerome Namias, *An Introduction to the Study of Air Mass and Isentropic Analysis* (American Meteorological Society, 1940), p. 158.

[31] John R. Borchert, "The Climate of the Central North American Grassland," *Annals*, Association of American Geographers, Vol. 40 (1950), pp. 23–24.

[32] John R. Borchert, "Regional Differences in the World Atmospheric Circulation," *Annals*, Association of American Geographers, Vol. 43 (1953), p. 19.

[33] John C. Bellamy, "Objective Calculations of Divergence, Vertical Velocity and Vorticity," *Bulletin of the American Meteorological Society*, Vol. 30 (1949), pp. 45–49.

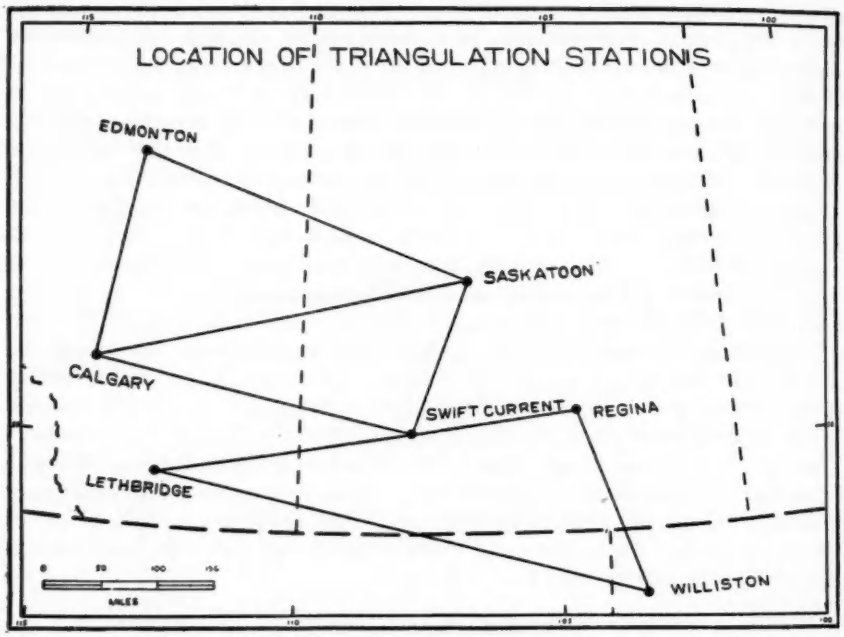


FIG. 26. Location of three triangles used in computation of horizontal divergence (Table I).

TABLE I

HORIZONTAL DIVERGENCE

Stations	Resultant wind		Horizontal divergence	
	Direction	Velocity	Partial	Total
Northern Triangle				
Calgary	303°	10.3 mph	−0.3	
Saskatoon	192	11.6	+0.3	
Edmonton	258	9.4	+0.1	
				+0.1
Dry Belt Triangle				
Calgary	303°	10.3 mph	−0.2	
Saskatoon	192	11.6	+0.8	
Swift Current	221	14.3	+0.9	
				+1.5
Southern Triangle				
Lethbridge	249°	13.4 mph	+0.1	
Williston	135	8.6	+0.3	
Regina	60	13.0	−0.4	
				0.0

roundings in terms of horizontal divergence. The Northern Triangle has a horizontal divergence value of only +0.1, while the Southern Triangle's horizontal divergence value is 0.0. The Dry Belt, with a value of +1.5, is thus marked in a local sense as a region of relatively strong horizontal divergence.

Studies of divergence aloft in so small an area as the Dry Belt are severely limited by insufficient coverage in both number of stations and length of record. Namias and Clapp have, however, mapped the distribution of normal fields of divergence and convergence over Anglo-America at 10,000 feet during February, May, August, and November[34] based on station coverage of a comparatively sparse nature. The location of the Dry Belt on these maps is definitely associated with regions of divergence during August and with zero value during the other months studied. Hence, it is clear that the Dry Belt is definitely associated with regions of divergence at the surface and aloft; in the former case, the divergence is quite distinct in a regional sense, differentiating the Dry Belt from its surroundings and clearly helping to explain its regional climatic character.

SUMMARY OF CAUSES FOR THE EXISTENCE OF THE DRY BELT

The Canadian Dry Belt forms a distinct climatic region on the basis of unifying characteristics of precipitation and temperature. Its basic climatic characteristic, deficiency of moisture, is the result of a number of factors which combine to prevent the area from obtaining as much precipitation as its surroundings.

The Dry Belt is frequented by considerably fewer cyclonic passages and more anticyclones than areas to the north and south; further, it lies south of one of the major Pacific air mass trajectories during the summer. The position of the jet stream during the summer, nearly 600 miles south of the Dry Belt in a location very near the axis of maximum frontal activity, places the Dry Belt in a vast feeding area of subsidence and divergence along the left side of the jet stream. Investigation of pressure distribution aloft—at both the 700 mb. and 300 mb. levels—indicates important areas of subsidence and divergence over the Dry Belt during the warmer part of the year when this area is markedly drier than its surroundings.

Studies of air flow across the highlands of western North America reveal that the Dry Belt lies along the northern margin of the first of two standing waves formed in the westerlies. This location along the northern edge of a large anticyclonic cell is in an area dominated at the surface and aloft by a dry current of air which winds eastward around the cell.

Finally, and most conclusively, the Dry Belt is clearly differentiated from areas to the north and south in terms of horizontal divergence. An area to the north has only a minor positive value, while to the south the value is zero; but the Dry Belt stands out with a value of +1.5. Generalized studies at an elevation of 10,000 feet indicate that divergence exists to that height over the Dry Belt part of the year.

[34] Jerome Namias and Philip C. Clapp, "Normal Fields of Convergence and Divergence at the 10,000-Foot Level," *Journal of Meteorology*, Vol. 3 (1946), pp. 20–21.

Surface Data Sources

Boughner, C. C., and Thomas, M. K. *Climatic Summaries for Selected Meteorological Stations in Canada, Newfoundland and Labrador. Vol. II, Humidity, Wind Speed and Direction.* Toronto, 1948.

Climatic Summaries for Selected Meteorological Stations in the Dominion of Canada. Vol. I, Average Values of Mean and Extreme Temperature, Mean and Extreme Humidity, Sunshine, and Precipitation. Toronto, n.d.

Currie, B. W. *Prairie Provinces and Northwest Territories: Precipitation, Snowfall, and Temperature.* Saskatoon, 1953.

General Summaries of Hourly Weather Observations in Canada and Newfoundland, 1949. Pt. I, British Columbia, Yukon Territory, Alberta, Saskatchewan, Manitoba. Toronto, 1949.

Joint Meteorological Committee. *Daily Synoptic Series, Historical Weather Maps, Northern Hemisphere, Sea Level, 1899–1939.* Washington, n.d.

Monthly Record; Meteorological Observations in Canada. Toronto, 1930–date.

Monthly Weather Review.

Pearce, D. C., and Gold, L. W. *The Canadian Snow Survey, 1947–1950.* Ottawa, 1951.

Schumann, T. E. W., and van Rooy, M. P. "Frequency of Fronts in the Northern Hemisphere," *Archiv für Meteorologie, Geophysik und Bioklimatologie,* Vol. IV (1951), pp. 87–97.

Thomas, M. K. *Climatological Atlas of Canada.* Ottawa, 1953.

Upper Air Data Sources

Mean Monthly Maps of 300-, 200-, 100-, 50-, and 25-mb. Surfaces Over North America. Washington, 1953.

Namias, Jerome, and Clapp, Philip C. "Normal Fields of Convergence and Divergence at the 10,000-Foot Level," *Journal of Meteorology,* Vol. 3 (March, 1946), pp. 14–22.

Normal Weather Charts for the Northern Hemisphere, Sea Level Pressure, 700-mb. Height and Temperature, Thickness (700–1000 mb.), 500-mb. Height. Washington, 1952.

Summaries of Radiosonde Observations in Southern Canada, Stations South of Latitude 55° N., June 1941–December 1949. Toronto, n.d.

THE NECESSITY OF WEIGHTING VALUES IN CORRELATION ANALYSIS OF AREAL DATA*

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University of Wisconsin

WHEN the geographer attempts statistical analysis, and especially correlation of distributions having areal extent, he must in many instances modify the general statistical formulae in order to take into account his areal point of view. This generalization applies when the data with which one is working are averages, percentages, ratios, or densities distributed over area and localized by minor civil divisions, counties, or some other such areal units: ". . . for correlation analysis has been designed for studying relationships between characteristics as distributed among units of equal importance."[1] When the areal units to which the values relate are not the same size, as is unfortunately usually the case, significant discrepancies in size should be taken into account; otherwise the results of computations may be meaningless.[2] The reduction of each value to a comparable unit, such as an average, ratio, or density, e.g., population per square mile or average slope, does not take care of the problem.

The weighting of values that apply to varying sizes of units in order to derive appropriate numerical generalizations is nothing new, and the geographer should allow for variations in areal extent just as the economist takes class frequencies into account. The graphic approach to an arithmetic mean via the cumulative graph, e.g., the hypsometric curve, is an example. Weighting different kinds of numerical values can and must be done in different ways depending upon the particular problem at hand; but in geographical problems susceptible to statistical attack, inequality of areal units is generally present. The actual area of the units can be used as a weighting medium although some small modifications of basic formulae are necessary; such data are usually available and can be rounded for computation according to the level of accuracy desired.

A simple example can make clear the difficulty of using non-weighted values in correlation analysis. Figure 1 shows three "states" of the same size within each of which there is an identical distribution of values x and y over the entire area. State I is composed of 6 "counties" of equal area (A). States II and III, although

* This short paper is a by-product of a study now in process and supported by the Graduate School of the University of Wisconsin. In addition I gratefully acknowledge the patient assistance of Professor R. A. Bryson of the Meteorology Department. The basic formulae are those in W. A. Neiswanger, *Elementary Statistical Methods* (New York, 1948).

[1] M. J. Hagood and D. O. Price, *Statistics for Sociologists* (rev. ed.; New York, 1952), pp. 354–356.

[2] Chance arrangements of the unit sizes and values may occur which would yield proper results even if no allowance were made for unequal sizes of units. On the other hand, computation to determine whether weighting were necessary would probably be more laborious than the weighting process.

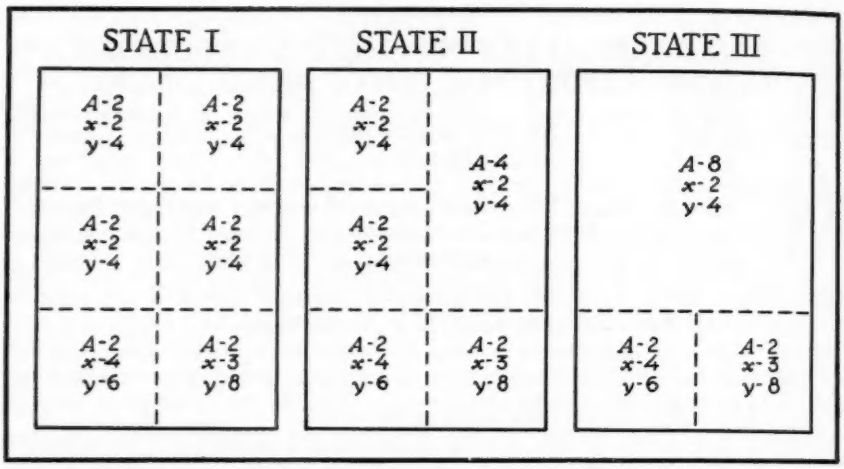

FIG. 1. Sample states for correlation analysis. The three states are of equal total area but differ in the number, size, and arrangement of counties. The area of each county is symbolized by A and the value of x and y for each is shown.

they have *exactly the same* total distribution of x and y, have different numbers and sizes of areal units or enumeration districts. The method of weighting by employing the areas of the units will also be shown with reference to values derived from this illustration.

CORRELATION

The formula for the calculation of the coefficient of correlation (r) from original values is

$$r = \frac{N \cdot \Sigma xy - \Sigma x \Sigma y}{\sqrt{N \cdot \Sigma x^2 - (\Sigma x)^2}\ \sqrt{N \cdot \Sigma y^2 - (\Sigma y)^2}}$$

in which N is the number of units and Σ is the summation sign. The following tabulation shows the values, derived from Figure 1, to be used in solving for r:

State	x	x^2	y	y^2	xy	N
I	15	41	30	164	80	6
II	13	37	26	148	72	5
III	9	29	18	116	56	3

When these unweighted values are employed the following values of r result, which are clearly incorrect in two instances since the distributions of x and y are identical in the three states:

State I $r = .715$
State II $r = .875$
State III $r = .500$

Of course State I gives the appropriate value since all its counties are the same size.

Clearly the coefficient of correlation for x and y is affected by the arrangement and size of counties regardless of the actual distribution of x and y. The influence of the chance arrangement of boundaries may be removed by weighting the data by the area of the units to which they refer. The formula then becomes

$$r = \frac{\Sigma A \Sigma Axy - \Sigma Ax \Sigma Ay}{\sqrt{\Sigma A \Sigma Ax^2 - (\Sigma Ax)^2}\ \sqrt{\Sigma A \Sigma Ay^2 - (\Sigma Ay)^2}}.$$

The following tabulation shows the weighted values, derived from Figure 1:

State	Ax	Ax^2	Ay	Ay^2	Axy	A
I	30	82	60	328	160	12
II	30	82	60	328	160	12
III	30	82	60	328	160	12

When these are used r is .715 in each case since the values are identical for each state.

THE REGRESSION LINE

The geographer may wish to work his correlation analysis via the regression line of Y on X by the formula $Y = a + bX$. In this instance a is the point of origin of the line on a graph when $X = 0$, and b is the change in Y for a given change in X. The two values of a and b are obtained as follows:

$$a = \frac{\Sigma x^2 \Sigma y - \Sigma x \cdot \Sigma xy}{N \cdot \Sigma x^2 - (\Sigma x)^2}$$

$$b = \frac{N \cdot \Sigma xy - \Sigma x \cdot \Sigma y}{N \cdot \Sigma x^2 - (\Sigma x)^2}.$$

Using the unweighted values of Figure 1 yields the following results:

State I $a = 1.429$ and $b = 1.429$
State II $a = 1.625$ and $b = 1.375$
State III $a = 3.000$ and $b = 1.000$

Quite obviously any estimates derived from the regression formulae would differ.

The formulae for a and b in the regression equation can be modified by multiplying each element by A and dividing by the square of the mean of $A(M_A^2)$. The formulae then become:

$$a = \frac{\dfrac{\Sigma Ax^2 \cdot \Sigma Ay}{M_A^2} - \dfrac{\Sigma Ax \cdot \Sigma Ay}{M_A^2}}{\dfrac{\Sigma A \cdot \Sigma Ax^2}{M_A^2} - \dfrac{(\Sigma Ax)^2}{M_A^2}}$$

$$b = \frac{\dfrac{\Sigma A \cdot \Sigma Axy}{M_A^2} - \dfrac{\Sigma Ax \cdot \Sigma Ay}{M_A^2}}{\dfrac{\Sigma A \cdot \Sigma Ax^2}{M_A^2} \quad \dfrac{(\Sigma Ax)^2}{M_A^2}}.$$

Since M_A^2 cancels out, the formulae can be rewritten in the the following form:

$$a = \frac{\Sigma Ax^2 \cdot \Sigma Ay - \Sigma Ax \cdot \Sigma Axy}{\Sigma A \cdot \Sigma Ax^2 - (\Sigma Ax)^2}$$

$$b = \frac{\Sigma A \cdot \Sigma Axy - \Sigma Ax \cdot \Sigma Ay}{\Sigma A \cdot \Sigma Ax^2 - (\Sigma Ax)^2}.$$

Using the weighted values, both a and b equal 1.429, the same value as that calculated for State I without weighting the values for the areas they represent. This is, of course, correct since all counties in State I are the same size.

THE STANDARD DEVIATION

If the standard deviation is computed from the list of values for each state in the usual manner, i.e.,

$$\sigma = \sqrt{\left(\frac{\Sigma x^2}{N}\right) - \left(\frac{\Sigma x}{N}\right)^2},$$

again a different value is obtained for each state. As in the case of the mean it is necessary to weight the values according to the areas each represents, i.e.,

$$\sigma = \sqrt{\left(\frac{\Sigma Ax^2}{\Sigma A}\right) - \left(\frac{\Sigma Ax}{\Sigma A}\right)^2}.$$

The result will then be identical for each state and correct.

It should perhaps be pointed out that in the calculation of the standard error of the mean N must be used.

STANDARD ERROR OF ESTIMATE

The short-cut formula for the standard error of estimate is

$$S_y^2 = \frac{\Sigma(y^2) - [a\Sigma(y) + b\Sigma(xy)]}{N}.$$

It should also be modified to take into account the relative sizes of the areas involved. The formula then becomes

$$S_y^2 = \frac{\Sigma(Ay^2) - [a\Sigma(Ay) + b\Sigma(Axy)]}{\Sigma A}.$$

SUMMARY

When making some statistical computations for geographical purposes it may be necessary to weight the values according to the relative sizes of the areas to which they refer. This is easily accomplished by employing the actual areas of the statistical units.

ABSTRACTS OF PAPERS PRESENTED AT THE 52ND ANNUAL MEETING OF THE ASSOCIATION OF AMERICAN GEOGRAPHERS, MONTREAL, CANADA, APRIL 1–5, 1956

CHARLES S. ALEXANDER—*Effects of a Pastoral Economy upon the Vegetation of a Desert Island*

On Margarita Island, Venezuela, acts of men have been unremittingly directed against the natural vegetation for so long as to modify or almost entirely change its form and distribution. Areas of truly natural vegetation are quite small; the remainder has been largely changed by man.

One of the most important factors involved in destruction of vegetation has been the grazing and browsing of livestock. In the mid-16th century Margarita was famous not only for fine quality cattle and goats, but also for horses and mules. Export of the latter to mainland South America was an important enterprise. The result of long-continued pressure of grazing and browsing has been the establishment of goats as the most important animal in the cultural landscape. A hardy forager, the goat has been able to thrive on increasingly inferior pasture while more discriminating animals have been forced out.

The consequences of goat herding have been twofold: in areas of smooth topography, as a result of selective browsing, the vegetation composition is being shifted to unpalatable plants; in areas of rolling and hilly topography, severe erosion is stripping away the topsoil over many square miles of surface. The vegetation zones on the island showing the greatest effects from over four hundred years of grazing are the mixed grass, brush, and cactus of the lowlands and foothills. Consequently, the lowland scene of Margarita Island is a desolate one of barren hills and thorn-scrub infested lowlands.

JOHN W. ALEXANDER—*United States Cities: Employment Category by Size of Settlement*

Question: How does each of 23 types of employment, distinguished by the United States Census, vary from small to large settlements in terms of percentage of a city's total employment?

Procedure: 302 urban settlements (157 urbanized areas plus other geographically independent settlements of over 30,000) were analyzed in terms of proportion of total employment represented by each employment category. The settlements were arrayed and grouped into 18 groups on the basis of population. For each category (e.g., wholesale trade) cities of each group were arrayed in terms of percentage of each city's total employment represented by that category. For each group three values were determined: (1) minimum percentage found in any city of the group; (2) maximum percentage in the group; and (3) median percentage.

For each employment category a triple graph was constructed of: (1) 18 minimal values for the 18 groups of cities; (2) 18 maximal values; and (3) 18 median values.

Results: The graphs revealed that for most of the 23 categories of employment there is: (1) strong positive correlation between size of settlement (by groups) and minimum percentage found in any particular group; (2) rather strong negative correlation between size of settlements and the maximum percentage; and (3) no very strong correlation between size of settlement and median percentage.

Conclusion: A new system for classifying cities by employment categories is possible in terms of surplus employment in each city in each employment category above minimum percentage prevailing for that category in that city's population group.

JOHN P. AUGELLI—*Aspects of Industrial Genesis in an Underdeveloped Area: Post-War Development in Puerto Rico*

To have lived on the Puerto Rican scene for any length of time in the post-War period is to have felt the dynamics of a profound economic change. Such change has touched every aspect of economic endeavor on the island, but perhaps it is in the phenomenal rise of industry that the transformation has been most marked. Since the industrial phase of "Operation Bootstrap" was initiated in 1947, hundreds of factories have been successfully established on the island, and new plants are joining the list at the rate of about one every four days. Growth has become so rapid that industrial statistics become obsolete almost as soon as they leave the caculating machines. "Seldom in my experience or in my reading," says ex-governor Rexford Tugwell, "have I encountered instances of such sudden, determined, and effective moods of enterprise as have risen . . . in Puerto Rico in the last decade."

What are the circumstances which created the climate for industrialization and economic change in an underdeveloped area shackled by a thick crust of agrarian tradition and largely lacking in raw materials, capital, and know-how? What industries are locating in Puerto Rico and why? What are the patterns and problems of industrial location and what effects are they having upon the landscape of the island? To what extent can the Puerto Rican experience serve as a pilot to industrialization and economic change in other retarded areas?

These are some of the questions which challenge the geographer viewing industrial genesis in Puerto Rico.

H. PHILLIP BACON—*The Townscape of Nashville, Tennessee, on the Eve of the Civil War*

On the eve of the Civil War, Nashville, Tennessee, was a prosperous flourishing river town. Two new suspension bridges spanned the Cumberland, the recently completed capitol crowned the loftiest point in the downtown area, a new courthouse graced the Public Square, homes and churches were being constructed, and the city was illuminated with gas lights.

The importance of the river to the city was much in evidence. Corporate outline and street pattern were riverine. Port facilities at the foot of Broad Street encouraged development of that area as the district for wholesale houses and commission merchants. Typical, too, was an undesirable section along the river front that housed a number of brothels, saloons, and criminal hideouts.

Nashville's commercial district remained in much the same area that had been established early in the nineteenth century. The Public Square, first retail center of the city, was in the process of change to a wholesale district. The retail shopping district expanded onto level terrain south and west of the Square. In 1860 no single section could be termed a manufacturing district. Small industrial establishments were located on most of the streets that formed the nucleus of the city.

The homes of the majority of Nashville's citizens were either within walking distance of the commercial district or on turnpikes leading into the city. As residential quarters expanded they encroached on low areas lying north and south of the nucleus, creating an increasingly serious flood problem.

MAURICE BERNARD BALLABON—*Some Aspects of Contemporary Economic Geography*

The growing opportunities for geographers in economic agencies and private industry require a re-evaluation of the content of economic geography. Its wide popularity rests on an uncertain methodology. It is not a study of the physical basis of economics, nor of the influence of the physical environment on economic activities. It is essentially a border-line subject to which both economists and geographers can contribute.

The earlier approaches, possibly arising from excessive emphasis on regionalism and training in the physical rather than social aspects of geography, were excusable when geographers saw their role as purveyors of "background material." Contemporary needs demand sharper tools. Economists, unfortunately, have not been too helpful in promoting an interchange between the two disciplines. Efforts to overcome this problem by up-dating geographers on trends in contemporary applied economics, or by selecting topics appropriate for geographical consideration are only temporary expedients.

No eclectic survey of economics is intended, and it would be presumptous to set up rigorous standards to cover the many divisions within economic geography. Space, like time, threads all economic activities. Possible improvements may come through the development of the "pure distance-area" concepts of Christaller, Zipf, and Lösch, or the more familiar establishment of observed spatial relationships between two or more phenomena. Major advances may have to await developments in locational theory and the concept of economic areas.

MILDRED BERMAN—*What Geographers Are Doing in Business: A Case History*

Employment opportunities for geographers in business are constantly increasing. One such opportunity is described here.

A Boston dairy company, suffering from an obsolete processing plant and congested transportation facilities, was desirous of finding a new plant location and of reorienting its branch structure. To solve the problem a task force, composed of geographers, economists, and marketing research experts, utilized both the cartographic and statistical approach.

On a large base map metropolitan Boston's main highways and connecting roads were shown, including those forbidden to commercial vehicles, those under construction, and future highway development. All Boston and Maine Railroad lines were shown since that line carries the company's milk from farm to plant. Wholesale volume and route boundaries plus areas covered by retail routes were plotted on acetate overlays for the base map.

Statistics in regard to hauling costs and population projections used in conjunction with the maps resulted in the selection of the new plant location and suggested the consolidation of several branch territories. Two maps showing how the new branch alignment and projected sales volume compared with the present branch and sales picture concluded the work of the task force.

The dairy company solved its problem, and marketing geography established another beachhead in the dairy industry. Since completion of the project a marketing research division has been created to carry on similar studies within the company. It offers at least part-time employment for a geographer.

ALBERT S. CARLSON—*Non-Geographic Factors in Resource Development: Illustrations from New England*

Non-geographic factors play a new and important part in the development of natural resources and location of new industry in New England today. These factors include private, semi-public, and governmental agencies that possess economic-geographic information and experts in plant location working to influence resource development.

These organizations and methods are increasingly strong influences and are actually a new form of governmental direction of resource use. New England has probably gone farther along this route than most regions, and the experiences of this approach offer valuable guide posts to all geographers interested in regional development. Examples of operating agencies and their success are numerous and provide a basis for the analysis of the relative value of geographic and non-geographic factors in resource development in New England.

CHING CHIEH CHANG—*The Chinese in Cuba and Jamaica: A Comparative Geographical Study*

Within the past century, hundreds of thousands of Chinese have left China for foreign lands. Because of unfavorable factors working against the Chinese migrating to countries outside of Asia, the number of Chinese entering intercontinental migration is small compared to the number entering intracontinental migration. Never-

theless, there are more than three hundred thousand Chinese in countries outside of Asia, and 70 percent of them are in the Americas.

In America, the Chinese are concentrated mainly in the United States, Canada, and the Caribbean area. Although the total number of Chinese in the United States and Canada is greater than in the Caribbean area, the number of Chinese per thousand population is actually larger on some of the Caribbean islands, including Cuba and Jamaica. As a result, it is in the West Indies that the Chinese have become important minority groups, while in the United States and Canada they are literally submerged in the huge population.

The object of this paper is to discuss the similarities and differences between the Chinese minority groups in Cuba and Jamaica as to geographical origin in China, route of migration, pattern of distribution, demographic composition, economic status and occupation, and social status and inter-racial marriage. The comparison is especially interesting because of the sharp differences between the two islands in history, racial composition, density of population, standard of living, and degree of economic development.

ANDREW H. CLARK—*Use of a "Control Area" to Test Hypotheses in Broader Regional Studies*

Geographers, as social scientists, lack laboratories for controlled experiments. The use of a "control area," in which certain factors are discovered to have relatively even incidence throughout the area for substantial periods of time, offers a promising substitute. Prince Edward Island, Canada's smallest province, is presented as an example of such a "control area" in the study of the significance of differences in cultural origin to differences in rural settlement and patterns and practices of land use in the much larger area of its neighbor, Nova Scotia. For example, Acadians and highland Scots each settled in scattered parts of Nova Scotia which differed substantially in physical character and in the force of social, political, and economic pressures. The same two groups are also clearly localized in Prince Edward Island, but there each unit, of whichever group, faced conditions of near uniformity wherever it settled.

The records of Prince Edward Island offer a wealth of locational data, allowing almost unparalleled detail for fine-grained mapping of population origin and land-use practice, throughout the period of European occupation. The significance of population origin in the agricultural and settlement geography can be discerned there with some confidence, and theories developed in Nova Scotia can be tested against the "control area." Its study, in turn, suggests ideas to be tested elsewhere if other "control areas" suitable for that purpose can be found.

JOHN WESLEY COULTER—*Economic Crisis in Hawaii*

The phenomenon of the great increase in the world's population is especially remarkable in Pacific islands where the movement of people away from an area is restricted by a wide expanse of ocean. In 1927, the population of the Territory

of Hawaii was less than 360,000. It increased steadily until about 1940 (423,330). World War II brought thousands of defense workers and hundreds of thousands of soldiers and sailors. There are now more than 500,000 inhabitants.

The Territory of Hawaii has reached and passed its peak in agricultural production which historically and traditionally has been the mainstay of the population. Some land formerly used for sugar cane and other agricultural purposes has made way for airfields, military reservations, barracks, and hotels. The first industry in the islands now, from the point of view of providing further development, is the tourist industry. Hotels, inns, and other accommodations are being made available at an extraordinarily rapid rate.

The tourist industry has had the effect of increasing the native consciousness of the Polynesians. However, Americans of Oriental parentage, hardworking and ambitious, take the lion's share of salaries and wages, and a feeling of antipathy has developed between Polynesian and Japanese. If an economic pinch develops, the former will be the first to suffer.

The Territory has weathered many economic storms since the beginning of its modern economic history, about 1840. Perhaps that augurs well for the future.

ALDEN CUTSHALL—*The Philippine Sugar Industry: Foundations and Prospects*

Production and milling of sugar cane hold dominant positions in the economic structure of the Philippines. In 1900, sugar production was limited to domestic demands. Cane was processed in crude mills using antiquated methods and was sold locally as muscovado or panocha sugar. A few muscovado and panocha mills are still in operation.

During the 1953–54 milling season 25 raw sugar centrals produced 1,400,281 short tons of centrifugal sugar, surpassing both domestic and foreign quotas for the first time since the war. This was the largest output on record and provided 30 percent of the total federal revenue. Most of the sugar is shipped to the United States.

The industry has achieved this position through a combination of physical, economic, and political factors. Most production is on the level plain of central Luzon and in western and northern Negros (more than 60 percent on Negros). Some planters and a few centrals are marginal producers and probably will be unable to compete on a duty free market.

Production of cane is characterized by a large number of small growers contributing only a small percentage of the total while a small number of large land owners produce the bulk of the crop. Only a very small proportion of the cane is grown by mill owners. Use of mechanized machinery and equipment in cultivation and harvesting has developed slowly. Only in the last decade has mechanization become significant. The real problem of the industry is in the field rather than in the factory.

PAUL C. DALRYMPLE—*Recent Developments in the North Atlantic Ocean Weather Program*

Northeastern United States and eastern Canada became extremely hurricane

conscious after hurricanes Carol, Edna, and Hazel in 1954, and Diane in 1955. Ironically, these storms followed the removal of Ocean Weather Station HOTEL at 36°40′ N latitude, 69°35′ W longitude, midway between New York City and Bermuda, on June 30, 1954. This station was at a position where its data would give forecasters an indication of the steering direction of hurricanes, especially of those passing westward of the station. At the 1954 Paris Meetings of the International Civil Aviation Organization (ICAO), Canada favored the continuation of Ocean Station HOTEL. The Canadian delegate maintained that the accuracy of landing forecasts for Canadian trans-Atlantic air terminals would be seriously reduced because of the extreme difficulty of forecasting the development and movement of storms passing northeastward between Bermuda and the United States. The United States has not reactivated the station, in spite of strong public agitation, but has increased its meteorological program in the eastern North Atlantic Ocean and Caribbean Sea. On September 1, 1955, Weather Bureau personnel were assigned to two merchant ships on scheduled trips between Baltimore and San Juan. The program was expanded between December 20, 1955, and January 20, 1956, when Weather Bureau personnel were assigned to three more ships on routes in the Caribbean Sea. These observations should result in better forecasts for southeastern United States, but will not replace Ocean Station HOTEL as a forecasting station for northeastern United States and eastern Canada.

PIERRE DANSEREAU—*Criteria for a Regional Description and Interpretation of Vegetation*

Plant geography and plant ecology have produced many techniques and methods for the study of vegetation. Very few of these are readily applied by geographers or indeed have actual relevance to the field of geography.

Historical plant geography contributes nothing to the description of landscape. For the most part phytosociological studies are too technical to lend themselves to geographically useful interpretations. Predominantly floristic approaches require too much taxonomic information which is otherwise irrelevant; whereas purely physiognomic descriptions lend themselves to very limited interpretation.

Examples are given of these various attempts at characterizing the botanical element of the landscape and it is suggested that physiographic and ecological categories provide the most useful primary background for the description of vegetation. The latter then should be defined in terms of structure, composition, and dynamics. Three different landscapes (Central Baffin, Northern New Zealand, and Southern Ivory Coast) are subjected to these criteria.

WALTER W. DESHLER—*The Study of Indigenous Population Distribution in a Semiarid East African Area*

Geographical field work in tropical Africa and in other non-Western areas is often hampered by the almost complete lack of basic population distribution data, such as are more readily available for the United States or Western Europe. For those remote areas which have aerial photograph coverage it is possible by analysis of the photographs and a scrutiny of the landscape to evolve indirect techniques

of measurement which may provide valid quantitative answers to the problems of population distribution and density.

By use of such techniques, settlement distribution for the Dodose country of northeastern Uganda was mapped, and population densities for selected areas were calculated.

The Dodose, a cattle-keeping Nilo-hamitic people who have had little European cultural contact, occupy an area of 4,000 square miles. Factors influencing population movement among these people are land exhaustion, disease of man and livestock, famine, threat of attack by hostile tribes, and government action.

The distribution of population in this area is uneven in the extreme. Over half of the area is uninhabited. The population has been compressed into clusters in the eastern part of the country. Many of the settled areas are overcrowded, with resulting pronounced land deterioration.

The existing distribution of people is clearly not stable. It is probable that stability in a rigid sense is neither possible nor desirable given the existing Dodose culture and landscape. Some easing of the maldistribution of population is indicated by barely discernible present population movement.

ROBERT E. DICKINSON—*The Braunschweig Industrial Area*

Space relations present special problems of physical planning and market reorientation in the phenomenal postwar growth of the Braunschweig industrial area. Situated midway between the Ruhr and Berlin, it lies inconveniently south of the main west–east railroad, but is closely connected with the Mittelland canal and the *autobahn*. Central in the pre-war Reich, its position is now eccentric, a few miles west of the Russian Zone. The area has three nuclei: Braunschweig (population, 230,000), heavily blitzed, but with remarkable revival of its diverse industries; Salzgitter (100,000), with rapidly reviving iron and steel industry, following the 1950 demolition, but with widely scattered residential districts; Wolfsburg (40,000), a compact town near the Volkswagen plant with 30,000 employees.

Problems of spatial development arise from the following: (1) one-sidedness of the industrial structure; (2) lack of housing, large refugee influx, and thus a long journey to work; (3) disrupted local communications along the zone boundary though the net of public services is mainly intact; (4) steel marketable against Ruhr steel as far as the Weser-Leine line and, since the natural market of central Germany is cut off, a present market area of a north-south belt between the Weser-Leine and the Russian boundary and including Hamburg. Here is need for development of north-south routes to reduce the journey to work; for increase of housing, services, and local routes; and for establishment of new industries in Salzgitter and Wolfsburg, with unhealthy dependence on one major industry in each center.

FRED E. DOHRS—*Heartland and World Ocean: A View of Soviet Geopolitical Theory*

Soviet geopolitical theory has often been so obfuscated by Communist claptrap

and quotations from Marx, Engels, Lenin, and Stalin that clear assessment of methodology and objectives is extremely difficult. In 1950, an article appeared in a minor Polish monthly, *Problemy,* which sheds considerable light on Communist geopolitical thinking. Both Mackinder's "Heartland Concept" and Mahan's "Unity of the Seas" are viewed from the Kremlin; a definite pattern emerges.

The Heartland appears as the Moscow-Kuzbas-Donbas triangle and acts as the base for expansion throughout the World Island. Because the world is three quarters ocean, ultimate mastery lies in the World Ocean, the center of which is southeastern Australia. If control of the World Island lies in the Heartland, control of the World Ocean, it is argued, lies in the Heartland of the seas.

The pattern of Soviet expansion and aggression indicates substantial adherence to this theory. Validity can be demonstrated and disputed under two main headings: (pro) the island bridge to Australia from southeast Asia makes a great peninsula-like extension of the World Island into the World Ocean, and coupled with control of Africa, effectively divides it into an Atlantic and a Pacific basin; and (con) control of the World Ocean by sea power must rest on an adequate land base, which neither Australia nor adjacent territory has sufficient resources to provide.

Evidence strongly challenges both debunkers of the Heartland concept and ardent proponents of air power, and may be of significance in the formulation of American foreign policy.

EDNA E. EISEN—*Liebbecke in Westfalia: A Community Study*

Liebbecke, with its population of 10,000 plus the British occupation forces, retains evidences of its medieval character. This picturesque city at the foot of the Wiehengebirge was then a fortified town. The same market place, Rathaus, church, and school stand in the center of the city. The Burgmanshof is typical of those days when a bishop ruled the town.

Today, the Burgmanshof is used as an office building. It belongs to a family who live on one of the nearby estates. For several centuries Liebbecke served as a market center for the estates and large farms of the rich loess plains. The farms are now predominantly small or medium-sized. The atmosphere of the old market center still prevails, although Liebbecke is now a service-trade center for the dominantly agricultural county.

Liebbecke faces serious housing problems. This is not due to war destruction. It is due, in part, to the occupation by British forces, but chiefly to the continuous influx of refugees from East Germany. Construction helps provide work to absorb the increasing population. Industrialization has grown. The manufacture of cigars is the largest industry. Besides having highway and railroad connections, Liebbecke is a port on the Ems-Weser Canal.

The people of Liebbecke, in keeping with the work pattern of West Germany, are working hard to provide themselves with homes, schools, recreation centers,

and hospitals. This city, which is definitely a mixture of old and new, is a comfortable place in which to live.

DAVID FIRMAN—*Current Expansion of Irrigation to Increase Food Production in the Gangetic Plain*

Considerable reliance is being placed on expansion of irrigation as a means of increasing food production in the Gangetic Plain. Present irrigation facilities are among the most highly developed in the world, but they are not adequate. Only 29 percent of the net cultivated area can now be irrigated. Both indigenous and state irrigation facilities are being expanded currently under a Fifteen Year Plan.

From the standpoint of available water resources alone, the irrigated area of the Gangetic Plain can be expanded much more than is planned within the next fifteen years. Limitations are imposed by the problem of increasing storage capacity to hold surplus run-off during the southwest monsoon. The solution, involving the adoption of new irrigation engineering techniques, is considered financially unfeasible at present. Fortunately, the use of groundwater is more promising. Irrigation can be expanded in nearly all parts of the Gangetic Plain by the construction of new deep wells.

An additional 9.1 million acres of the net cultivated area in the Gangetic Plain will be under irrigation by 1971. It is estimated that approximately 0.183 tons of food grains will be added to the annual production of each irrigated acre. This will provide about 1.7 million tons of food grains annually, or 14.5 percent of the increase needed to feed the population. Thus, expansion of irrigation alone cannot be expected to offset food deficits. It is possible that irrigation in conjunction with widespread improvements in agriculture will supply enough food grains to maintain the present low level of nutrition.

ERIC FISCHER—*Some Comments on a Geography of Religions*

Geography of religion is a special branch of social geography and can be an indicator of social structure. So far religious allegiance has been traced mainly on the basis of statistics. Statistics can lead only to a certain point, however, because they invite early generalization and suffer from lack of exact localization. In mapping, denominational differences tend to be suppressed and attitudes toward one's religion are not shown. Relations to other fields of social geography are not sufficiently explored. Though history shows many instances of mutual influence of religion and political events, the influence of religion upon the present political map is little explored. Religious allegiance can change gradually under the impact of political conditions; but little detailed knowledge of change of this type has been assembled.

It is possible to overcome some of the limitations of religious geography by use of detailed field observation. Dress, habits, and architecture can provide material. There are difficulties. Some religions are not given to open display. Therefore,

to the casual observer, the religion of minorities may appear to predominate in some places. Outward forms of a cult may survive under changed conditions. Such facts provide difficulties of interpretation; but they can be overcome, and advances are possible.

R. LOUIS GENTILCORE—*Early Agriculture in the Vincennes Area, Indiana, 1735–1830*

The Wabash Valley was an important link in the extensive system of water transportation developed by the French in the eighteenth century. Of the posts established along the route, only Vincennes developed some sort of civic life and could be considered a town. As such it fostered a unique agricultural activity, favored by a physical environment that included large areas of prairie land and alluvial soil. A wide variety of crops were grown, including wheat, tobacco, and fruit, but corn was the staple. Livestock numbers were substantial with the cattle usually kept in a large common pasture ground enclosed by a fence.

However, it was the fur trade and not the working of land that formed the basis for French life. This was reflected in haphazard and inefficient methods used to record land grants. The movement of Americans into the area brought with it a new appreciation of agriculture and value of land. But the impression upon the French was not a lasting one. Land granted them by the American government was soon traded to land-hungry Americans, thus encouraging migration into the area at a time when the frontier of settlement lay well to the east of the Wabash.

Herein lies the French contribution. For almost a hundred years they had occupied land well in advance of general settlement. Their mere presence attracted others. As newcomers proved themselves better able to take advantage of the agricultural possibilities of the land, the French passed out of the picture.

J. SULLIVAN GIBSON—*The Land-Use Type as a Geographical Tool*

Early work in agricultural geography followed largely the commodity approach. The geography of agricultural regions became a popular approach in the 1920's and continues to the present. In the 1930's and 1940's agricultural economists contributed valuable grist for the geographer's mill through type-of-farming studies. These three approaches place heavy emphasis on the economics of agriculture—the "how much" and the "how good" of production—slighting somewhat the "look" of places and areas.

The land-use type geographic study emphasizes such factors as size of operation, layout pattern of fields and pastures, physical imprint made by cultivation, method of handling, system of tenure, and environmental limitations, in addition to quantity and quality of production. This approach supplies much of the "look" of agriculture that is missing in the other approaches. It emphasizes the activity or occupation of agriculture, particularly as it effects change in the environment; in so doing

it balances the pure economics of agriculture against the non-economic, resulting in a broader picture.

Small-scale hill-farming, practiced in many areas, represents a distinct land-use type. Scale of operation is small and a patchy pattern prevails, with a small proportion of total area farmed. Individual areas show strong similarity whether the dominant crop be corn, potatoes, garden vegetables, or a combination of all, and whether the type be located in the Appalachians, the Ozarks, or tropical highlands. The type, or system, of using the land and the imprint of such use on the environment dominate over individual crops.

BERL GOLOMB—*Reclamation and Utilization of an Apparent Wasteland*

Twenty-five hundred years ago basalt lava flows overran corn fields and villages of archaic man in the southwestern corner of the Valley of Mexico. Over a reniform area of 85 square kilometers vegetation was destroyed, animal life was obliterated, and man was expelled. The lava field, a small, yet distinct geographic region, is known as the Pedregal (The Stone Wasteland).

Far from being a stony desert, the Pedregal supports a profuse and diversified vegetation. It has been a refuge for plants and animals, safe from the environment-changing plow. As a catchment area it efficiently transmits precipitation to the underlying ash and cinder beds. The Pedregal is an easily exploited source of building stone and gravel. Livestock are pastured on the Pedregal. Lava-free clearings are tilled within it. A footpath network connects the tilled clearings with villages on the Pedregal's margins. The lava field is a popular recreational area, conveniently combining scenic landscape with accessibility and proximity to Mexico City.

More remarkable than this gradual integration is the direct incorporation of sections of the Pedregal into Mexico City's urban landscape. As quarries clear back the rock, the reclaimed space is being settled. The *Ciudad Universitaria* (University City) and a large residential development were recently established directly on the Pedregal. Over five square kilometers have already been thus reclaimed. The Pedregal, which till recently has been a fertile field for geologists, geomorphologists, and ecologists, is now entering the realm of the urban geographer.

DONN K. HAGLUND—*Recent Economic Developments in the Godthaab District, Greenland*

Godthaab is undisputedly *the* nerve center of west Greenlandic economy. Since 1947 it has been the administrative focus for all Greenland. In 1954, with the opening of the 210-bed tuberculosis sanatorium, it became the health center of the island. The settlement has a population of 2,300—greater than that of any other in all Greenland.

The new Danish Constitution of 1953 altered the political status of Greenland, and the Greenland Provincial Council, representing all west Greenland, convenes each August at Godthaab.

Housing and other construction in Godthaab has been spectacular. A new residential area, called "East Town," has been built. The new warehouse at the harbor will greatly augment Godthaab's function as distribution and receiving center. An electric plant rapidly nears completion.

Plans are under way to move the Godthaab Radio from the peninsula to the Cook Islands, and, with increased power, to give a much greater signal range.

Activity at the South Greenland Press has intensified; two newspapers, numerous government publications, and academic aids are printed.

There are now several private enterprises in Godthaab, including an ice cream store, a general store, a grocery, a photo-radio store, and a coffee bar.

Slower growth is taking place in outlying settlements. The most striking is the construction of new fishery plant warehouses at Kapisigdlit, Q'ôrnoq, and Fiskenaesset.

The reindeer experiment at Itivnera is achieving success; the herd now numbers 650. The sheep experimental station at Q'ôrqut has provided gratifying results; however, the unsuccessful fox fur farm experiment at Godthaab was abandoned, at least temporarily.

ELEANOR E. HANLON—*Twenty Years of Change in a Portion of the Rural-Urban Fringe of Syracuse, New York*

This paper presents in detail the changes which have occurred since 1935 in agricultural land use and settlement in a section of the Oneida Lake littoral.

Twenty years ago this 18-mile long extent of low-lying glacial lake plain, only 12 miles northeast of Syracuse, was almost completely rural. Except for a little recreational activity associated with a summer influx of city people to shoreline cabins, the focus of the economy was on dairy farming with some poultry raising and truck gardening. Today the situation is very different. Industrial expansion of Syracuse, especially on its northern fringes, and the general sprawl of the urban area, have had a rapid and visible impact upon the rural Oneida Lake plain.

There has been a marked (approximately 40 percent) increase in population along the littoral, accounted for largely by the growth of rural-nonfarm occupance on the outskirts of the four small villages, along the recreational shoreline fringe and in the open country. Farms have decreased in number and have changed in size, management, crop emphasis, and relative importance in the area.

By comparing maps, aerial photos, and data collected by the writer in 1936–37 with similar materials gathered in 1955 in selected portions of the area, these changes are recorded and interpreted.

F. K. HARE—*The Forest Geography of the Peninsula of Labrador-Ungava: Report on a Program of 1 to 1,000,000 Aerial Survey*

A group at McGill University recently completed an aerial survey of the forest geography of Labrador-Ungava. The original survey was completed on the 1:500,000 scale, and the field-sheets have been reduced to the 1:1,000,000 scale

for presentation to the Association. Similar physiographic maps will be presented to make clear the obvious correlation between vegetation and surface type.

The mapping is physiognomic in nature, and has confirmed and strengthened earlier views concerning the structure of Boreal vegetation put forward by Hustich, Hare, Rousseau, and others. The group believes that its methods of survey, which have made it possible to cover half a million square miles in five years, will also be applicable to the world land use survey.

JOHN FRASER HART—*Recent Changes in British Agriculture*

Tremendous changes have taken place in British agriculture since the days before the Second World War. Approximately six million acres of permanent grassland—one third of the total acreage in 1938—were plowed up between 1938 and 1944, but more than a million acres had reverted to permanent grass by 1951. Cropland increased from 8.5 million acres in 1938 to 13.7 million by 1944, but two million of these acres had been taken out of crop production by 1951. Between 1938 and 1951 rotation grassland steadily increased at an average annual rate of approximately 100,000 acres; an average of more than 30,000 acres annually reverted to rough grazings.

Tractors have rapidly replaced horses, which dropped from 1,001,526 in 1938 to 432,239 in 1951. The cattle population increased from eight million in 1938 to nine and a half million by 1951. Cattle are largely replacing sheep in lowland areas, but sheep remain dominant in the uplands, although sheep numbers have been reduced by unusually severe winters. Pig and poultry numbers have fluctuated sharply with varying availability of feed stuffs, but by 1951 they had essentially returned to pre-war levels.

These over-all changes are the resultant of regional changes which in some cases tend in opposite directions and thus conceal the true magnitude of the changes which have taken place. This paper is a cartographic analysis, on a county basis, of regional variations in Britain's most recent agricultural revolution.

C. H. HERBERT—*The Development of Transportation in Northern Canada*

The most difficult and urgent problem in the economic development of the Northwest Territories is transportation. The problem is partly one of distance between mining centers and sources of supply; other factors are inherent in the nature of the region. High transportation costs are a consequence, affecting all enterprises in the Territories.

Cheapest transportation is by water; the Mackenzie River system has borne the brunt of this. Its use is handicapped by long winters and interruptions in the waterway, such as rapids in the Slave River. Late-season shallow water, shifting channels, and storms or ice on the lakes are other hazards.

The second route into the Mackenzie valley is by highway, 380 miles from railhead at Grimshaw to Hay River on Great Slave Lake. The road is linked to Yellowknife by tugs and barges across Great Slave Lake. High cost of operations

has restricted the amount of freight carried to and from Yellowknife by this route. The main southbound freight is fish from Great Slave Lake.

Aviation has done much to open the Northwest Territories. Scheduled services extend from Edmonton to Aklavik on the Mackenzie and Coppermine on the Arctic seacoast. Perhaps the greatest contribution of aviation has been through unscheduled services, serving remote areas.

The Eastern Arctic has no regular surface transportation. Passengers and freight are carried by coasting vessels and by air.

Proposals for improved transportation include the building of a railway to Hay River, a considerable expansion of the highway network, and an increase in scheduled air routes.

HOWARD F. HIRT—*Historical and Cultural Influences on the Land-Use Pattern of Aligarh, U. P., India*

Aligarh, U. P., a city of about 150,000 population, is an administrative, manufacturing, commercial, and educational center located eighty miles southeast of Delhi in the Ganges-Jumna *Doab*. The city was founded by the Hindus at least one thousand years ago. It was conquered in 1194 A.D. by the Moslems, whose various dynasties ruled it until 1784. After a brief interlude of Maratha rule, the English captured the city in 1803 and governed it until 1947, when it again came under Indian control.

The land-use pattern of present-day Aligarh shows the impact of these successive stages of occupation. The oldest part of the city stands on an eighty-foot-high mound of debris steepened and fortified by the Hindus. The nearly six hundred years of Moslem rule are reflected by the narrow, winding streets, colorful bazaars, and congested residential and workshop quarters of the older parts of the city. The English rulers were responsible for the growth of a westernized residential and administrative area with wide, straight streets, large bungalows, and extensive lawns, called the "Civil Lines." Between the Civil Lines and the old city are a main railroad line and an area of large-scale industrial enterprises, hospitals, and crowded Indian residential quarters that form a zone of transition between the Indian and the westernized sections of the city.

JORDAN A. HODGKINS—*The Energy Potential of Soviet Russia's Coal Fields*

Coal and lignite rank in first place among the energy resources conventionally and currently used for power production in the Soviet Union. Data concerning reserves of these resources are usually presented in tons. Tonnage, however, is not a measure of energy value, but of quantity. In this study, Soviet coal reserves are examined in terms of their energy potential, the calories and kilowatt-hour content per coal field, rather than tons per coal field.

Computations of energy potentials for the individual coal producing regions were based on Soviet determinations of the cal/kg of the various types of coal and lignite in each field.

The greatest energy potential lies not within the European, or established, industrial centers of the Soviet Union, but within the coal fields of western and eastern Siberia, between the Kazakh Republic and Lake Baikal, and south of a parallel passing through Moscow. This high concentration of energy potential occupies an area less than one third the size of European Russia.

Coal fields in the southern sector of western Siberia alone have a greater kilowatt-hour content than those of the Pechora, Moscow, Ukranian (including Donets), North Caucasus, and Transcaucasus fields combined. The Siberian area has eight and one half times the energy potential of the Urals combined with all the fields of Turkestan, including Karaganda.

GEORGE W. HOFFMAN—*The Role of Nuclear Power in Europe's Future Energy Supply*

In many European regions cheap conventional energy resources have been used so extensively that they are rapidly coming to an end. On the other hand, many energy resources have been unused because of unfavorable geographical location or technological difficulties, while other resources are being exploited for reasons of national self-sufficiency only.

Therefore, planning for Europe's dwindling electric energy supply can be divided into two closely related problems: (1) closer international cooperation among European countries which will bring about larger transfer of electric power across European boundaries and thus the establishment of special industrial zones located close to the available power supplies, and (2) joint technological developments which will result in economically operated reactors which can feed the large heat potential of nuclear fuel directly into the present thermal power plants and others that may evolve.

Obviously, in those countries having cheap and abundant energy resources, the use of nuclear fuels is only justified if power costs are not greater than presently used fossil fuels or the energy of falling water. On the other hand, in those European countries where resources are unevenly distributed or dwindling, cost factors will become secondary to the availability of sufficient energy resources. Estimates vary on the economic rentability of nuclear fuels and will differ greatly for different European countries. Once the problem of financing the investment for new plants has been solved, nuclear fuels will play a decisive role in the economic geography of Europe between 25 and 30 years from now.

JOHN C. HOOK—*The Areal Variation in the Value of Agricultural Land and Buildings in Northeastern United States*

The purpose of this study is to investigate some factors associated with the areal variations in value of agricultural land and buildings in northeastern United States. County data from the 1950 Census of Agriculture and the Census of Population are used throughout.

The degree of association between variables is measured by simple and multiple

product moment coefficients of linear correlation. Most observations and subsequent generalizations are based on a random sample of 100 counties (28 percent of the universe).

There is a fairly close relationship between value of agricultural production and value of agricultural land and buildings ($r = +.85$). This relationship is expressed by the regression equation

$$VLB = 2.40\,VP + 28.4.$$

VLB is the value of agricultural land and building per acre, and VP is the value of agricultural products sold per acre of farmland. The standard error of the estimate is $66.60.

Differences between the actual value of land and buildings and the value computed from the above formula were mapped. It was found that the formula gave poor results in many counties located near metropolitan centers. This indicates that value of agricultural land and buildings in such areas is not a function of agricultural production; rather, it is related to the accessibility of the metropolitan center. Distance from nearest metropolitan center (U. S. Census definition) was subsequently introduced in the formula which is now stated as

$$VLB = 2.22\,VP - .73\,DNM + 49.00.$$

DNM is the straight line distance from the center of the county to the center of the nearest metropolitan center.

RICHARD J. HOUK—*Some Significant Aspects of Portugal's Fishing Industry*

Portugal is a country poorly endowed with natural resources except for valuable coastal fisheries; therefore, the utilization of this resource has proved to be of basic importance in the economic development of the country. In the days of early settlement along the Portuguese coast, wherever natural protection existed, there developed centers of appreciable population whose inhabitants secured an important part of their subsistence from the fish catches. Gradually, fishing gear and fishing methods have improved, resulting in the securing of a greater quantity and variety of maritime catches. Today, the maritime fishing industry is exceeded only by agriculture and manufacturing as a means of livelihood in Portugal; more than 100,000 fishermen and their dependents derive their income directly from fishing, and some 35,000 other Portuguese are dependent upon the preparation and distribution of fishery products.

The purpose of this paper is to present a descriptive survey of the fishing industry of Portugal which explains the present importance of this activity to the Portuguese people and their national economy. This involves a consideration of: the historical development of the Portuguese fishing industry; the location of the various Portuguese fishing grounds; the varying methods of exploitation used; the significant characteristics of the processing and distribution of the products of the Portuguese fishing industry; and recent developments in this industry.

W. A. DOUGLAS JACKSON—*Durum Wheat: A Struggle for an Essential Food in the USSR*

In the struggle for improvement in the quantity and quality of wheat production in the USSR, considerable attention is focused on the vital role which increased sowings of durum wheat must play. In the USSR, durum wheat yields a flour whose baking quality exceeds most other wheats grown. Yet, there is evidence to indicate a decline in both acreage and production since the Revolution.

Durum wheat is grown primarily along the southern margin of the spring wheat region. It served in the 19th century as a pioneer crop par excellence, accompanying the settler into the semi-arid steppe. It yielded well on virgin lands. But as "hard" lands were reduced to "soft" lands through continuous cultivation, yields fell and common wheats replaced durum.

The Soviets aim to solve the problem by ploughing millions of acres of virgin lands, but the utlimate solution depends on improved agricultural techniques, including sound fallowing practices.

PRADYUMNA P. KARAN—*The External Forms of Indian Cities*

As a result of compiling a list of the larger cities of northern India and of constructing maps showing external form, six well-marked types of urban development have been noted; viz., elongated, triangular, circular, semicircular, rectangular, and irregular.

The purpose of this paper is to analyze the principal causes for the evolution of each of these types. Rivers and roads appear to be responsible for elongated forms; towns such at Patna, Lucknow, and Kanpur have elongated shapes due to the control of river-fronts. Triangular form is related to convergence of roads at one apex, to a road crossing a river, or to some restrictive force in the site. Rounded or circular towns owe their form to growth around a central fort and market; many of these have fortifying walls. The semicircular plan is due to some limiting line (such as a curved river bank) along one side of the town. A rectangular pattern is related to a "cultural dominant," such as a rectangular fortifying wall, or a natural growth at cross-roads. The largest group of towns have an irregular form. Historical vicissitudes; distribution of firm or loose soil, or low-lying or raised land in the site; unequal pull of various roads controlling the commercial connections of the town with the surrounding areas; the position of the railway station and the administrative section; and the location of the market places—all these are factors which appear to have contributed in varying degrees to the irregular form of many cities.

FRANK L. KELLER—*Emerging Land Patterns in Guatemala's Alta Verapaz—An Interim Report*

Fear of agrarian reform, including land redistribution and increased rural wages, and a recent indication of a downward trend in coffee prices are forcing

finqueros in the Department of Alta Verapaz, Guatemala, to reappraise present methods of coffee culture toward making individual estates more efficient by less dependence on large reserve acreage and abundant, cheap labor.

How one important coffee producer is meeting this challenge may be described as typical of a developing trend which promises to reshape both commercial and subsistence land-use patterns in the region. Where formerly some 40,000 acres were potentially available for the establishment of *cafetales,* new coffee plantings are now concentrated along the existing transportation route through the estate. Excess land is released to Indian families who are working for a wage on the *finca.* Individual coffee trees are planted close together. Nowhere are new *cafetales* located far from the road connecting the main house with the highway leading to the point of export, Puerto Barrios. Careful seed selection is made prior to planting new *cafetales.* Formerly soil condition was an important location control, but social and economic factors often take precedence over physical conditions; if other locational factors determine that a given area would be advantageous for coffee, the soil, if considered poor or overworked, is heavily fertilized. Cattle furnish manure and cost-defraying by-products.

Development of large-scale mining enterprises in the southern portion of the region also has a significant impact on the emerging land-use pattern of the Alta Verapaz.

HENRY MADISON KENDALL—*Crop Combinations in the North American Northeast*

The method devised and applied by Weaver to Midwestern agriculture is applied to that of the northeastern United States and adjacent Canada for the primary purpose of providing an expanded base for further study and analysis of method. The same crops are used despite well recognized differences between the economies of the two areas. Whether the method provides a developable basis for geographic analysis or not rests partly upon its application to a sufficiently large portion of the world's occupied area. Patterns resulting from this particular study are considered to be an extension of evidence, not an end in themselves.

A total of 16 crop combinations exists in the North American Northeast. Of these, four are found in 76 percent of the counties included in the study. These are: hay monoculture, concentrated in New England, eastern New York, and West Virginia; the hay-oats combination, through New Brunswick, Quebec, and eastern Ontario; the hay-oats-wheat-corn combination, from Ohio through Pennsylvania into western New York and New Jersey; and the hay-corn-wheat combination, in the southeastern part of the total area. The other combinations occur as transitions or as local variants of the four principal ones.

Certain difficulties arise. The county grid obscures detail of pattern. The use of standard crops omits certain specializations which are more truly descriptive. Variations in agricultural intensity and relative significance are not evidenced. Despite these handicaps, the validity of expanding the base for future analytic studies is not destroyed.

LESTER E. KLIMM—*Regional Description Based on Texture and Pattern of Unit Areas*

This is a preliminary report on a search for methods suitable for making descriptive generalizations and comparisons of cultural landscapes with reference to the texture and pattern of the unit areas which compose them. It is a part of a larger investigation of the process of descriptive generalization in geography.

A map of Pennsylvania showing six major land-use classes has been constructed at a scale of 1:250,000 from aerial photography. This map shows some sections of the state to have relative homogeneity of land use over large areas; others are characterized by extreme fragmentation and diversity.

Sections vary as to the number of classes of land use present, the proportion of each, the sizes of units of each, the shapes of units, the degrees of clustering or dispersal of the units, or their orientation.

This project seeks to find methods of measuring and describing these characteristics in order to regionalize on the basis of the nature, number, size, shape, and arrangement of unit areas.

Some methods of analysis already investigated which show promise of usefulness are: line traverse (probably by "random walk") on segments of the map to gather basic data; index of circularity to measure one aspect of shape; Lorenz curve technique applied to arbitrary areal subdivisions to measure evenness of distribution of units; standard radial deviation as a method of describing the arrangement of units; and coefficient of mean distance to nearest neighbor as a measure of spacing of units.

HIBBERD V. B. KLINE, JR.—*Dynamics of the Geography of Rice in Sierra Leone, West Africa*

The tribal peoples of Sierre Leone practice a rice monoculture, other edible crops being additives to the rice diet or substitutes in times of shortage. Upland rice is produced by shifting cultivation, employing axe, fire, and hoe, and the use of a field for one cropping season only. Population pressures in this century have reduced the bush fallow periods drastically, leading to serious soil depletion and erosion and to dangerously small food supplies.

Four lowland situations are recognized as suitable for wet rice:

1) Coastal mangrove swamps. Indigenous cultivators developed a major rice concentration on the Scarcies Delta, but government polders have failed and similar swamps elsewhere are virtually unused.
2) Inland swamps, particularly on the crystalline piedmont. Government measures have resulted in notable swamp clearance, but the farms are not popular and the pressure on adjoining uplands is not significantly reduced.
3) Riverain grasslands flooded by the southern rivers. These are essentially uninhabited and the physical conditions for farming are so difficult that little progress has been made.
4) Grassy floodplains (bolis) where the central courses of large rivers cross a sedimentary belt. They are considered amenable to mechanical cultivation, which had a small beginning in 1952.

Despite the apparent potential of the lowlands, upland rice cultivation continues to dominate. Currently the food deficits are met and the "hungry season" kept at bay by government importation of Italian and Burmese rice.

This paper analyzes the geographical implications of the struggle to make Sierre Leone self-sufficient in its staple foodstuff.

DUANE S. KNOS—*The Distribution of Substandard Housing, Kansas City, Missouri*

This study is concerned with the following question: What factors may be used to explain variations in the areal distribution of substandard housing in Kansas City, Missouri? The census for 1950 lists the number of dwelling units which are dilapidated and/or lack basic sanitary facilities. Ratios of such units to total units in blocks are used as measures of substandardness.

Seven independent variables are hypothesized to be associated with substandardness. These are: (a) average rents, (b) neighborhood status rating, (3) percentage of dwelling units, (c) overcrowding, (d) occupation by non-whites, (e) distance from major thoroughfares, (f) distance from C.B.D., and (g) distance from industrial districts.

Coefficients of correlation (r) are computed between the dependent variable (Y) and each of the independent variables, and tests for significance are applied. The highest correlation is found between substandardness and average rents (−.672) and the lowest between substandardness and non-whites (.312). All the coefficients are statistically highly significant, but none explain more than 45 percent of the variance of substandardness.

Since a more complete explanation is desired, the multiple coefficient of correlation (R) and beta coefficients are computed. When tests of significance are applied to these measures the non-white variable is found to be not significant. Therefore, a new coefficient (.920) is computed using the remaining variables. The nature of the association is

$$Yc = .92AR + 12.0NSR + .81OC - 11.1MT + 4.27CBD - 2.66ID - 144.2.$$

Deviations of estimated from actual values of Y are mapped to describe areal variations in the associations.

DAVID H. KORNHAUSER—*The Nature and Function of City Planning in Japan*

As in other countries, city planning in Japan is largely urban redevelopment and most of this has come about since World War II. Although the Japanese government recognized the city planning function as early as 1919, the first major application came after the Kanto earthquake of 1923. Tokyo was "modernized," but only the downtown portion was substantially changed. The periphery remained largely unplanned and disorderly. On the local level between the wars, urban planning was aimed primarily at eliminating inconsistencies in design. As in Tokyo, nearly all activity was concentrated in central business districts.

World War II destroyed most major cities and offered opportunity for revisions on an unprecedented scale. The result was a new crusade of city planning. Weak

finances were a limiting factor and often general administrative confusion, inexperience, or dogmatic leadership led to inadequate realization and consequent public apathy. The most significant handicap was the basic structure of the city itself. Even after the most severe bombing this usually remained a hodge-podge of ancient and semi-modern forms. In some cities faults were eliminated; in others, merely perpetuated. Many of these conditions existed in the West when city planning began. Yet there are interesting differences engendered jointly by the physical peculiarities of the Japanese city and by divergent cultural backgrounds.

The effectiveness of postwar city plans in Japan has seemed to rest largely on the quality and the nature of the leadership, for public participation has been at best only a negative force.

HUEY LOUIS KOSTANICK—*Modern Athens: Its Evolution and Functions*

Modern Athens contains nearly twenty percent of the total population of Greece. Its fantastic growth and the concentration of over eighty percent of the country's industry in the city pose both political and economic problems of major proportions to the Greek state. These questions of urban growth and population concentration can be answered best by a study of the historical evolution of the city and of the continuity or change of its functions.

Early development was favored by the defensibility of the rocky Acropolis which dominates the large Attic plain. Curiously enough, such defensibility became a critical issue for all of Greece in 1947, when only the Acropolis and nearby Constitution Square remained as nuclei for successful liberation of Greece from Communist guerilla control.

Such historical constancy of function also remains in Athens' commercial position as a hub of both land and sea routes to which has been added both national and international air linkage. Similarly, the Attic plain has continued to be one of the leading productive areas of Greece; the loss of arable agricultural land through urban encroachment has been offset by a substantial modern industrial development.

The most critical index to the changing fortunes of Athens appears to be its political role at any particular period. For example, modern growth is closely linked with territorial expansion of the Greek state. Athens today is the leading Greek city and the largest capital of the Balkans.

A. W. KÜCHLER—*Vegetation Maps in Geographical Research*

A brief discussion of the various approaches to the study and classification of vegetation is followed by a short analysis of those geographical problems to whose solution vegetation maps can contribute materially.

These basic statements lead to a discussion of practical methods to apply vegetation maps to geographical research. Means of selecting the most appropriate type of vegetation map and of interpreting the map content are emphasized.

URBAN J. LINEHAN—*Areal Distribution of Tornado Deaths in the United States*

This paper summarizes and attempts to explain the areal distribution of tornado deaths in the United States for the 38-year period 1916–53. Basic source of data is the United States Weather Bureau tornado log; most important supplementary sources are newspapers, disaster statistics of the American National Red Cross, and accounts of storms in meteorological publications. Deaths are located in the county where they occurred, and most of them with reference to some specific place.

The approach is geographic; chief techniques used are statistical and cartographic. Distribution of deaths is portrayed on a dot map, using a one-to-one dot scale. Four major tornado-death regions are delimited, statistical data compiled for each, and a quantitative comparison made of salient tornado-death characteristics of adjacent regions. An explanation of regional contrasts in the distribution of deaths is attempted in terms of relevant physical and cultural factors, with emphasis on meteorological conditions and number and distribution of people.

In spite of a probable gradual decline in number of tornado fatalities as a result of improvements in tornado warning services, the fundamental control exerted by frequency and violence of the storms themselves, together with number and distribution of people, make unlikely any abrupt changes in present broad regional contrasts in the distribution of tornado deaths.

RICHARD F. LOGAN—*Suburbia in the Sun—the Desert Boom in the Southwest*

Since World War II, southern California, Nevada, and Arizona have undergone tremendous population increases. While concentrated primarily in urban areas, a most astounding development has occurred in the area formerly most shunned by travelers and residents alike—the desert. Large tracts, some over 100 miles from major urban centers, are taking on suburban aspects. Several factors have caused this: (1) the "discovery" of the desert by Americans—who only recently have come to appreciate its beauty, its climate, and its solitude; (2) technological advances permitting comfortable desert living; (3) the desire to escape from the sprawling urban areas of the West Coast; (4) the increase in smog; (5) the availability of cheap government land; and (6) real estate promotion.

This expansion usually begins with a recreational aspect: dude-ranching, luxury resorts, or simple week-end houses on five-acre "jack-rabbit homesteads" provided by the federal government. But invariably some week-enders become permanent residents. Some are supported from outside (pensions, investments, etc.) or live by creative ability (writers, artists, etc.); but many try to find local employment. Thus local Chambers of Commerce are recently trying to attract industry to the desert—thereby bringing the city to the very people who are trying to flee from it. Military installations employ many—but also remove large tracts from private entry.

Modern developments contrast sharply with earlier settlement attempts in that they have no agricultural base, benefit greatly from modern conveniences, permitting comfortable living, and are served by excellent transportation facilities.

DAVID LOWENTHAL—*Standing Room Only: the Population Anomaly of Barbados, B. W. I.*

The British West Indian island of Barbados has a population density of 1400 per square mile—greater than that of any other land in the New World and all except a few spots in the Old. Even in terms of arable land per person, Barbados is unique. Furthermore, almost every arable acre of the island's 167 square miles has long been under cultivation; and every five years the population increases by a number greater than the whole labor force in the sugar fields and factories which alone sustain Barbados. Yet there is so little concern among the people about the population situation that, according to one high government official, only a devastating hurricane can solve the problem.

This paper analyzes the geographical and historical reasons for Barbados' population anomaly, the key determinants today, and the island's future prospects. The following conclusions emerge: (1) no substantial reduction of population or increase in national income can be expected from emigration, industrialization, land reform, increased sugar production, or replacement of sugar by subsistence agriculture or by other export crops; (2) a radical reduction of the rate of natural increase through birth control, now vigorously promoted by the government, remains the only alternative to disaster. However, even should the government overcome religious and political resistance and popular apathy and ignorance, and attain its immediate goal of lowering the birth rate as rapidly as medicine and sanitation have reduced the death rate, Barbados' population in 1986 would still be over 300,000, or 1900 persons per square mile.

PAUL E. LYDOLPH—*A Comparative Analysis of the Dry Western Littorals*

Precipitation characteristics of west coast deserts of North and South America, Africa, and Australia are compared to detect precipitation controls common to all areas and to arrive at some quantitative measure of the relative magnitudes of individual controls in each area.

Correlations between surface phenomena and investigations of the vertical structure of the atmosphere along these coasts indicate that a coastline paralleled by cool ocean water is a climatic factor conducive to aridity. Precipitation amounts are most significantly correlated with the degree of exposure to the major oceanic and atmospheric circulations.

The factors controlling precipitation are: (1) control of surface air temperatures by a cool sea, (2) normal atmospheric subsidence within a subtropical high pressure cell, (3) additional subsidence along a cool-water coast, and (4) local effects.

Normal subsidence at an optimum can reduce annual precipitation to about nine inches over a latitudinal distance of one or two degrees and will allow a precipitation of approximately four inches per degree in either direction from the minimum point. The additive effects of surface contrasts can reduce precipitation to zero

at the point of maximum subsidence and can hold it at that level against the waning effects of subsidence to low latitudes so long as active contact with the open-ocean circulation is maintained. Where surface contrasts are maintained at an optimum to higher latitudes their effects can reduce precipitation by three-fourths or more, but cannot hold it at zero. Surface contrasts are most important in summer.

J. Ross MACKAY—*Oriented Lakes of the Liverpool Bay Area, N. W. T., Canada*

The north-south oriented lakes of the Liverpool Bay area extend from Point Atkinson one hundred miles east to Cape Bathurst in an area of sand and silt that lies mostly within fifty feet of sea level. Two types of oriented lakes are present: (1) large lakes that are shrinking in size through infilling by polygonal ground, and (2) small lakes that are increasing in size through coalescence and elongation of ponds developed on polygonal ground.

Strong prevailing winds blow across the lakes, a relationship observed by others for the oriented lakes near Point Barrow, Alaska, although lake orientation there has been ascribed to Pleistocene winds that blew along the length of the lakes.

Significantly, the three large concentrations of oriented lakes in North America —the oriented lakes of the "Carolina Bays," Point Barrow, and Liverpool Bay— are all in coastal plains of unconsolidated sediments that have been partly submergent during or since the Pleistocene epoch. There is strong evidence for modern wind control of the oriented lakes of Liverpool Bay and Point Barrow. Wind control might have formed the Carolina Bays. Whatever the origin of the lakes may be, lake orientation in the Liverpool Bay area is a present continuing process.

VINCENT H. MALMSTRÖM—*Lappland: Northern Europe's Stategic Problem Area*

Although Lappland is politically shared by Norway, Sweden, and Finland, it may well be considered a single region, united by common economic and social problems. Among these problems are isolation and neglect. The region has retained many of the characteristics of a primitive frontier, its standard of living is lower than that of the rest of Northern Europe, and the influence of Communism is disproportionately great.

World War II and its aftermath, the "Cold War," turned the national attention of all three countries on Lappland. In both Norway and Finland extensive programs of reconstruction were necessary. In all three countries the intrigues of the Cold War have pointed up the region's strategic importance.

Lappland embraces more than 145,000 square miles and has a population of over one million. From detailed examination of the area's economy, it is concluded that, while each national segment of Lappland is overwhelmingly dependent on a single industry, and is thus unstable, this is not true of the region taken as a whole.

Since the end of World War II, Norway, Sweden, and Finland have all endeavored to solve the problems of their respective segments of Lappland. Though

each country's plans have been sketched out in terms of its own national interests, those of Finland require international cooperation for their realization. How far international cooperation can proceed, however, hinges to a great degree on the Cold War and the widely differing roles that it has caused the three sister nations to play.

EUGENE COTTON MATHER—*Five Major Ranch Types of the Central Great Plains*

The rangelands of the Central Great Plains formerly supported one of the simplest and most uniform types of economy. Today, the patterns of ranching have become highly diversified. These patterns reflect not only physical and economic elements which are variable within the Central Great Plains, but also human factors which are not economically based. Many of the essential characteristics of the ranching systems are not revealed by statistical analyses of group data but are depicted by field studies of individual ranch types. This investigation attempts to portray the elements of the chief systems of ranching within the region by means of selected ranch type studies. Five ranches are mapped and analyzed. They are: (1) transhumance type of cattle ranch in south-central Colorado; (2) combination dry farming–cattle ranch on the plains of northeastern Colorado; (3) dry range cattle ranch on the dissected plains of the Powder River country of Wyoming; (4) combination sheep-cattle ranch of the western South Dakota butte district; and (5) cattle ranch of the Sand Hills and sub-irrigated meadows of Nebraska.

ALBERT J. P. MCCARTHY—*The Irish National Electrification Scheme*

Development of electricity in Ireland is significant for two reasons: although there was no electricity outside the major cities at the formation of the Free State, electricity will be available throughout the Republic by 1960; and, because the Republic has no oil and very little coal, the scheme will rely largely on peat for fuel.

In 1923 Dublin and Cork had steam electric generating plants, but there was no electricity for sale elsewhere. The first step toward further electrification was the Shannon hydroelectric scheme. Later, stations were constructed on the Liffey near Dublin and the Erne in the northwest. Hydroelectric works are under construction on the Lee in County Cork and in Donegal.

The Electricity Supply Board has divided Eire into working units of approximately 25 square miles each. This year it announced that half the districts have been electrified. A national grid has been established and the country is small enough so that power can be transmitted economically throughout the land.

Eire's hydroelectric potential is severely limited. Hence, the Electricity Supply Board plans to use peat to the greatest possible extent as fuel for steam stations. This technique has been used in Germany and the USSR as the most economical way of exploiting peat. Two methods for extracting peat mechanically have been devised, as well as a new technique for utilization.

Electricity will play an important part in the effort to increase manufacturing

in Eire. A tremendous change in the landscape will result from the removal of the bogs.

HAROLD H. MCCARTY—*Use of Certain Statistical Procedures in Geographic Analysis*

We are concerned with a research procedure consisting of the following steps:

1) Examination of problem data to determine mean, variance, skewness, etc.
2) Plotting data on an isopleth or choropleth map generalized according to parameters discovered in Step 1.
3) Examination of geographic literature and selection of hypotheses accounting for variations noted in Step 2.
4) Visual comparison of problem map with maps of independent variables noted in Step 3.
5) Analysis of association between problem data and variables discovered in Step 4 by means of scatter diagrams, regression lines, standard errors of estimate, and coefficients of correlation.
6) Use of regression equations to compute deviations of actual values (Y) from estimated values (Yc). These deviations (Y – Yc or Yc/Y) are plotted on new maps which show distributions of the unexplained variance of Y.
7) Repetition of steps 3 and 4 for the new map; selection of other independent variables.
8) Incorporation of new variables into the analysis; computation of a new (multiple) regression equation; repetition of Step 6.
9) Continuation of routine until desired degree of association is achieved.

This involves the statistical measurement of associations detected visually from a comparison of maps. Present concern is with the adequacy of various statistical methods used for this purpose.

Tests using data for employment in manufacturing in civil divisions of the United States indicate superiority of multiple regression analysis over other methods. Simple and multiple coefficients of correlation present distinct advantages over correlation from ranks, coefficient of geographic association, and first moment correlation.

TOM L. MCNIGHT—*Aircraft Manufacturing in Texas*

During the last decade and a half the manufacture of aircraft and aircraft parts in Texas has become one of the state's leading industries. In 1939 the aircraft manufacturing industry was practically non-existent in Texas, but today it employs some 50,000 workers, which is six percent of the national total and represents ten percent of the industrial employees in all Texas factories.

This expansive recent growth stems largely from the establishment or relocation of five major producers in the state. Federal government contracts account for nearly all production; thus strategic considerations have been of paramount significance in fostering the development. Other "location factors" of note include availability of land, accessibility to airfields, adequate surplus labor supply, an abundance of flying weather, relatively inexpensive utilities, and considerable local inducement (such as temporary waiver of city taxes).

All of the major aircraft manufacturers and most of the minor ones (largely subcontractors) are located in two northern Texas counties—Dallas and Tarrant. In late 1955 Fort Worth was the sixth largest aircraft producing center (as measured by employment) in the nation, and Dallas ranked tenth.

The history of this development is dramatic, the current status is volatile, and the future is uncertainly promising; but the aircraft manufacturing industry apparently has come to Texas to stay, and as such it plays an increasingly important role in the economic geography of the local areas involved and the state as a whole.

MARY MEGEE—*Germanium and Gallium: A Study of Some Economic Aspects of Two Rare Metals*

The development and use of the so-called "rare metals" have increased so greatly within the last two decades that a study of their occurrence, production, and uses seems significant. The purpose of this paper is to deal with two—germanium and gallium.

Both are found in relative abundance in nature, germanium accounting for 4 to 7 grams of each ton of lithosphere and gallium for about 15 grams per ton of lithosphere. Very rarely are they sufficiently concentrated for feasible recovery. Both are obtained primarily as by-products of British coal ash and flue dusts, as by-products of the recovery of cadmium from Tri-state zinc sulfide ores, and as by-products of complex copper ores of Southwest Africa.

Germanium is a metalloid with properties between that of a true metal and a non-metal, and is classified with those materials known as semiconductors. Gallium probably presents some of the most unusual properties of any metal: (1) a wide liquid range from about 30° C. to almost 2000° C. and (2) expansion upon freezing, creating a packing problem for producers.

Germanium is consumed largely in the forms of dioxide, tetrachloride, and high purity metal; gallium, as oxide and high purity metal. Statistics are difficult to obtain, but annual productions show marked increases, especially since 1941.

Uses have also increased. With increased production it is expected that an increased number of uses will be found, particularly in the fields of electronics and atomic energy.

ALEXANDER MELAMID—*The Impact of the St. Lawrence Seaway on the Economy of Cleveland (Ohio)*

This paper is the result of the author's work on industrial locations carried out as part of a report on "Cleveland and the Seaway" prepared by James C. Buckley, Inc., Terminal and Transportation Consultants, for the city of Cleveland. The purpose of the report was to forecast the volume and character of Cleveland port traffic after completion of the St. Lawrence Seaway and to make recommendations regarding the terminal facilities and industrial land acreage required to handle this traffic.

After delimitation of the hinterland of Cleveland and its potential traffic, estimates were prepared regarding future ocean-freight rates and the resulting volume of traffic. Since this traffic will be affected by the volume of industrial operations within Cleveland, the effect of the new transportation facilities on the location of industries in the city was investigated in the light of current industrial trends. This industry study provided data on the acreage requirements of new plants which, together with the data for anticipated traffic, were utilized to draft recommendations for the improvement of port and ancillary facilities.

According to the report Cleveland can be expected to handle about 9 percent of Seaway traffic. To handle this traffic and to provide the necessary land for industries the construction of eight or nine general cargo berths is required together with the relocation of existing activities on Cleveland's waterfront and a total public expenditure of $23 million.

DAVID H. MILLER—*Landscape and Climate: Topographic Influences on Heat Supply at the Earth's Surface*

When principles of physical geography are applied to problems involving topography, the concept of *adret* and *ubac* slopes, expressed as number of hours of sunshine, does not go far enough. Often what is most necessary is information on the rate at which heat is supplied to the earth's surface, in such units as calories per square centimeter. Although this element is very significant in a regional climate, it has seldom been measured directly, and means of estimating its areal distribution are needed.

Relations between heat supply and topography can be developed from observations of the disappearances of a snow cover, by integrating longwave and shortwave radiation, convection, and condensation into the total heat budget. On a day of rapid melting in the Sierra Nevada, heat supply to a concave northwest slope was 300 calories per square centimeter, while to a convex south slope it was 475 calories. Difference is attributed to more direct insolation on the south slope (not merely more hours of sunshine), lower albedo of snow, convexity and warmer air, and more absorption of radiation by trees. Each landscape element can be studied separately; for example, a change of ten degrees in orientation of a slope is associated with a change of 3 to 5 calories per square centimeter in daily heat supply. This figure can be termed the "caloric equivalent" of orientation. Studies of caloric equivalents of terrain elements are proposed for interdisciplinary research by geographers and meteorologists, to advance the joint study of landscape and climate.

MALCOLM A. MURRAY—*An Exploratory Study in Urban Medical Geography*

Selected cities of Ontario and southern Ohio-Indiana are compared with respect to mortality differences for certain cause-of-death categories. Explanations of differences are attempted on the basis of geographic investigation of these cities.

Investigation and consequent explanations depend upon detailed knowledge of the cities derived from statistical sources, personal observation, interviews, correspondence, and land-use data plotted on maps.

The cities chosen include Brantford and Woodstock, Ontario; Middletown, Ohio; and Connersville, Indiana. Brantford and Middletown are of comparable population size, as are Woodstock and Connersville. Statistically significant differences occur between certain cities for tuberculosis, motor vehicle accidents, homicide, suicide, cardiovascular diseases, and cancer. The categories of total deaths, diabetes mellitus, pneumonia and influenza, and other accidents show no significant differences among any of the cities.

In general, mortality from tuberculosis, motor vehicle accidents, homicide, and suicide is greater in the Ohio-Indiana cities. Mortality from cardiovascular diseases and cancer is higher in the Ontario cities. In addition, Brantford and Woodstock show interesting mortality differences for tuberculosis and cancer.

On the basis of this study it is possible to present an adequate account of differences in mortality for three of the cause-of-death categories: tuberculosis, motor vehicle accidents, and homicides. Although mortality differences from suicide, cardiovascular disease and cancer are not entirely accounted for, possible theories of the etiology of such causes of death have been examined.

This study attempts to explain the observed mortality differences in the light of established scientific knowledge, not to attempt a revelation of new causative mortality factors.

PETER H. NASH—*Evolving Acceptance of Geographic Thinking in City Management, Community Planning, and Urban Renewal*

City management and city planning are recently evolved professions. Their recent successful, simultaneous growth parallels development of scientific urban geography. Municipal management and urban planning have developed on the basis of common philosophies. Urban activities, functions, and plans are increasingly developed on a "wholesale" rather than "retail" basis. Thus the utilization of a geographical approach is one of the most striking of the similarities. Each profession has helped and re-enforced the other both in principle and in practice; both are generalists in the same area in addition to being specialists in different activities. Recently the roles of these professions have undergone similar and closely interrelated changes.

The federal government crystallized geographic thinking in the official requirements for utilization of slum clearance and urban redevelopment provisions of Title I of the Housing Act of 1949. This basically sound Act was not sufficiently comprehensive; a broader approach was imperative. "Urban Renewal" is a new comprehensive term introduced by Public Law 560 in the Housing Act of 1954; it not only includes clearance and redevelopment, but also neighborhood conservation and rehabilitation. The 1954 Act shows a greater concern for people than for things.

A seven-point Workable Program is required of an urban area to qualify for federal financing. The mandatory Comprehensive Community Plan and Neighborhood Analyses require geographic treatment in terms of areal analysis, synthesis, and demonstration or relationships. Many cities and towns are submitting geographic studies to the Urban Renewal Administration, H.H.F.A., thus providing an invaluable source of facts, maps, statistics, and constructive ideas for urban geographers.

CLARENCE W. OLMSTEAD—*The Role of Lake Michigan in the Orchard and Vineyard Fruit Industry*

Along the eastern shores of Lake Michigan are some of the most specialized fruit-growing districts in eastern Anglo America. Their presence has often been explained as resulting from the cooling of westerly winds by Lake Michigan so that blossoming along leeward shores is retarded until danger from spring frosts has passed. What are the observed relationships of Lake Michigan to these specialized orchard and vineyard areas?

1) Lake Michigan's role as a water route for shipment of perishable fruits to Chicago and Milwaukee was essential to the beginnings and early development of commercial fruit-growing in western Michigan.

2) The cooling of surface air by Lake Michigan waters does operate to retard plant growth along the shores of the lake in spring but, apparently, along *all* shores. The result, along all shores, is reduction, not elimination, of the spring frost hazard.

3) The air-conditioning effect of Lake Michigan results in advantage for eastern over western shore areas only when the flow of surface air is from a westerly direction. This is true of most invasions of polar continental air in winter and early spring. It is the reduction along eastern shores of freeze damage from such invading cold air, combined with the more general shore phenomenon of retarded spring warming, that is essential to commercial orcharding.

4) Other factors, such as orchard management or the nature and distribution of land types, significantly modify the effect upon trees and vines of the Lake-moderated air.

SVENN ORVIG—*The McGill University-Arctic Institute Carnegie Arctic Program*

In 1951 the Carnegie Corporation of New York made a grant for arctic studies to McGill University and the Montreal Office of the Arctic Institute of North America. The grant included one senior fellowship per year for five years and several scholarships annually, also for a five-year period. The summer of 1956 will be the last field season under the original Carnegie grant, and it is perhaps now the right time to sum up some of the experiences and results from this scholarship program.

The program has deliberately not been directed into a few lines of research, but rather the students have been encouraged to frame their own problems. The

work has centered on botany, geography, geology, parasitology, sociology and anthropology, and zoology.

Thirty-four students have been supported under the scholarship program, and all but four have carried out at least one season's field work in the Arctic or Subarctic. Eleven completed theses had come out of the work of the scholars by the autumn of 1955: four for the M.Sc. degree and seven for the Ph.D. degree. Many more are at present in preparation. The arctic scholars have come from seven different countries, with Canada and England leading the list. They have done field work in Alaska and Greenland, but mainly in the Canadian Arctic.

JAMES J. PARSONS—*The Green Turtle* (*Chelonia* spp.): *A Diminishing Food Resource of Tropical Seas*

The giant green turtle (*Chelonia* spp.), renowned for its highly edible flesh, is widely distributed through the warmer seas of the tropical world. In the past an important protein food resource, it is today threatened by destructive rates of exploitation. The female is particularly susceptible to capture because of her habit of returning regularly to the same nesting beaches to breed and to lay eggs. The natural history of these giant herbivores is probably less well known than that of any other animal of comparable economic importance which has suffered such depletion in numbers.

The nesting grounds of the green turtle are highly localized geographically. Small islands off the continental shelves free from predators are especially favored. Major centers for turtle-turning and egg-collecting include the Great Barrier Reef of Australia and the islands of Torres Strait, certain small islands off the north coast of Borneo and in the Moluccas, Ceylon and the Seychelles Islands in the Indian Ocean, and isolated Ascension Island in the South Atlantic. In the Caribbean there remains only one major nesting ground, a 20-mile stretch of black sand beach in Costa Rica known as Turtle Bogue (Tortuguero). The important commercial catch of the Cayman Island turtle fleet, which supplies the United States market, is taken at the Miskito Cays off the Nicaragua coast. These turtles are not turned on the beaches, however, but are netted at night while grazing on underwater pastures of turtle-grass.

CLYDE P. PATTON—*A Quantitative Assessment of the Thornthwaite Classification of 1948*

An interesting feature of the Thornthwaite climatic classification is the consumption of water surplus as a by-product of the empiric calculation of potential evapotranspiration, the basic element of the classification. This paper attempts to assess the validity of Thornthwaite's empirical formulae by comparing the derived values of water surplus with observed values of runoff.

The comparison is made in California, an area of diverse relief but of characteristic precipitation regime. It is presented in two ways:

1) The comparison is made graphically, by maps depicting lines of equal runoff and equal water surplus, and by maps comparing individual drainage areas. Important anomalies mar the general similarity of the maps. These disparities are, in part, related to differences in meaning of the terms "water surplus" and "runoff," to differences in soil moisture capacities, and most importantly to the character of the underlying rock which affects the percentage of water surplus that becomes surface runoff.

2) The comparison is made statistically. The coefficient of correlation is high (.875) and is statistically highly significant (at the .05 percent level of confidence), even though none of the disturbing factors mentioned above are taken into consideration.

Since the statistical correlation is high, and much of the difference between water surplus and runoff can be explained by the behavior of water once it passes into the soil, it follows that Thornthwaite's values of potential evapotranspiration must be of the right order of magnitude for this area of summer drought.

DONALD J. PATTON—*The External Port Relations of Halifax and St. John*

The ports of Halifax and St. John in the Canadian Maritime Provinces are complementary and competitive with each other and with the St. Lawrence ports; and competitive with the North Atlantic ports of the United States. They represent twin foci of circulatory systems subject to pronounced seasonal changes. Traffic circulation patterns through these ports are the resultants of involved complexes of political, economic, technical, and physical factors. An analysis of the external relations of the ports suggests some aspects of the forces which influence the circulation of traffic.

Hinterland traffic of the Maritime ports is composed of a winter and a year-round component. Hinterland relations in the special winter import and export trade are conditioned by grain export control, by differing rail access to both ports and to the piers within the port of St. John, and by differences in port facilities. Long-haul summer traffic is maintained, despite the competition of Montreal, by commodity and class rate structures; market absorption; organization of shipping in the North Atlantic; and other factors. Hinterlands of both winter and year-round traffic consist of a series of disconnected areas.

Orientation of the seaward trade links toward three distinct areas (Northwest Europe, Middle America, and Southeast Asia) relates not only to imperial preference and the gross pattern of world trade routes. Site aspects of St. John and Halifax and broad forces in Canadian history are likewise involved in the attraction of particular phases of ovearseas traffic to the Maritime ports.

LOUIS O. QUAM—*The Arctic Research Program of the Office of Naval Research*

The Office of Naval Research supports a program of research on Arctic environment and its effects on life and human activities. The greater part of the program

is carried out at the Arctic Research Laboratory at Point Barrow, Alaska; but field studies are also conducted in other parts of the Arctic and Subarctic of North America and Europe.

The Arctic Research Laboratory has been in operation since 1948. It provides modern well-equipped laboratory facilities and instruments for conducting physiological, ecological, and geophysical studies. It also serves as a base of operation for field investigations and can provide small craft for limited oceanographic observations. Although the Navy and Air Force have conducted many applied research tasks at ARL, some of which are classified, by far the greater part of the research program is conducted by civilian research institutions and universities and deals with fundamental scientific problems.

The Arctic Research Laboratory is administered by the University of Alaska, and the Arctic Institute of North America assists the Office of Naval Research in developing and coordinating the research program. To date thirty other universities, twenty government agencies, and four research institutions have participated in the basic research programs; and a total of 218 scientists and technicians have conducted or assisted in research tasks.

The program for the current field season includes sixteen projects and forty-two investigators. Nine of the projects are in the field of the biological sciences and the other seven in physical science. Although this division may not be the proper or desirable balance, it does indicate that the program includes all fields of science which contribute to an understanding of Arctic environment and which present problems which require investigation in an Arctic location.

Other field projects include studies in glaciology, geomorphology, regional geography, hydro-biology and geophysics in Arctic and Subarctic areas. In addition, ONR together with the Army and Air Force support the Arctic Institute project on the Arctic Bibliography. Five volumes of the Bibliography have been published and the sixth has gone to press.

ARTHUR H. ROBINSON—*A Method for Expressing Quantitatively the Correspondence of Mapped Distributions*

Central to much, if not most, geographic analysis is the manner in which two (or more) related distributions covary over area. The nature of the covariation is an expression of the similarities and differences from place to place and constitutes our basic set of peculiarly "geographic" facts. A departure from a defined "normal" covariation, i.e., an "anomaly," is merely another aspect of the facts from which the analysis proceeds.

A fundamental difficulty has been our inability to express quantitatively the irregularities of the covariation partly because of the problem of relating unlike distributions to a common standard. Instead we have made visual judgments of the correspondence (or lack of it) between the mapped distributions. Such judgments are subject to indeterminate error, and, not being quantitative, are unsuitable for subsequent precise analysis.

A simple method by which the relation between areal distributions can be quantitatively expressed is demonstrated. Two isopleth maps of Nebraska are used to illustrate the technique. That there is a varying degree of covariation between the distributions of rainfall and density of farm population is obvious. The two numerical distributions are normalized (i.e., brought to a common standard) by using the regression line technique. Then the amount by which one distribution corresponds positively or negatively with the variations of the other can be expressed in quantitative terms. Several methods of normalizing the data can be employed depending upon the degree of precision desired, and the technique can be applied to more than two distributions.

HOWARD G. ROEPKE—*Changing Sources of United States Mineral Supplies*

An examination of the sources of some 30 important minerals commonly used in the United States (most of them classified as either "Strategic" or "Critical") reveals several important facts. Generalizations about increasing United States' dependence on foreign sources of minerals are only partly true. When the situation in 1950 is compared with that in 1913, fifteen of the minerals examined show significant differences in the proportion of our total supply imported. In seven of these fifteen, nearly half, we are less dependent on imports now than 40 years ago. To reveal more recent experience, the paper also compares the present situation with 1937, and it examines the volume and relative importance of the minerals involved. With respect to minerals imported, examination shows that significant changes have occurred in the importance of various areas of the earth as suppliers of minerals to the United States. A critical assessment of the importance of various supply areas including consideration of weight, bulk, and possibility of substitution leads to the conclusion that the picture of our strategic dependence may be less black than commonly painted.

RICHARD J. RUSSELL—*Team Research in Geography*

Team research may be defined in various ways. As research conducted simultaneously and as a joint venture between two or more persons with differing specialties, team research is most appropriate in geography for the reason that geography is such a diversified field. From the research standpoint lasting contributions are most likely to involve one or more related, adjacent disciplines, rather than to lie centrally within the core of geography. If the true merit of geographers consists of ability to interpret and synthesize research findings of specialists in related disciplines, the proposition that team research is desirable hardly can be questioned. This thesis is supported by examples.

JONATHAN D. SAUER—*Recent Plant Migrations and General Biogeographic Theory*

The distribution patterns of organisms at particular moments in time are transitory stages of ceaseless migrations. The more biogeography is concerned with

understanding of processes rather than describing situations, the more urgent becomes the need for a clear picture of migration dynamics. Unfortunately, for most of geologic time, direct evidence is so incomplete that attempted reconstructions of migration processes are better taken as interesting guesses than as foundations for a science.

Much less speculative reconstructions are possible for geologically recent time, thanks mainly to glaciers and man, both causing rapid migrations of countless organisms, both leaving a datable record of events in the process. Not only are these recent migrations worthy of study in their own right, but they can also give priceless insight into general principles of migration, provided allowances are made for certain peculiarities of continental glaciers and the human race. A rich store of concrete data on recent plant migration, some scattered through literature of diverse branches of science, some awaiting field investigation, has not yet been assimilated into biogeography.

A hasty preliminary survey of actual case histories suggests certain new concepts of the mechanics and rate of the migration process and indicates that the genesis of plant distribution patterns is often more intricate than has been assumed in deductive reconstructions.

CYRUS J. SHARER—*The Growth of Nassau*

The first permanent European inhabitants of the Bahama Islands arrived in 1647 from Bermuda and settled on the edge of the archipelago at Eleuthera, the point nearest Bermuda, 800 miles northeast. By 1666, as growing interests in exploitation of local resources and advantages began to offset Bermuda's maternal pull, the center of population began to shift from Eleuthera towards the center of the island group. A settlement, soon to be known as Nassau and destined to become the capital, was formed at that time on New Providence.

Early settlers suffered many hardships through a period of piracy and frequent reprisals from Spanish and French. Using the ingenious techniques of the amphibian, however, they managed to hold on until the end of the American Revolution when arrival of many Loyalists and their slaves brought about the superimposing of a cotton-growing economy on the traditional seagoing way of life. Decline of cotton foreshadowed the end of slavery in 1838, and later agricultural ventures were also shortlived. The sea, though, was harvested with much more success and today provides the necessary subtropical setting for Nassau's most important industry, the tourist trade.

From its start the population of Nassau rose gradually, though unevenly, until about 1800. After that there was general slowing down of growth until the 1920's. Since then, Nassau, focus of the Bahamas, has been growing so rapidly that over half the Bahamian population is now on New Providence.

ROBERT M. SPARKS—*An Analysis of Locational Changes in the Broad Woven Fabrics and Narrow Fabrics Industries between 1945 and 1955 in Pennsylvania Counties of the Philadelphia Standard Metropolitan Area*

This paper is based on 250 personal interviews (14 in the industries considered),

conducted by the writer between July 1954 and September 1955, and industrial plant location data developed by the staff of the Philadelphia Industrial Land and Facilities Study. The industries are divided into wool and non-wool categories and examined from five avenues of approach: rate of change, type of change, patterns of distribution, motivation of changes, and relationships between plant movements and certain cultural and physical factors in the subareas involved, including movement patterns of other industries.

The investigation shows marked acceleration in the movement of wool fabric firms since 1951, whereas non-wool fabric firms moved at a rather steady pace throughout the period in question. Quantitative comparisons are made by calculating the movements as percentages of the average number of firms between 1945 and 1954. The differential in plant changes in wool is the result of a wave of liquidations. Plant movement is mapped for the five counties on the Pennsylvania side of the Philadelphia Metropolitan Area. Origins and destinations are pinpointed, distances calculated and weighted by employment, and azimuths averaged. With the pattern of movement defined, an attempt is made to assess motivation factors mentioned in the interviews. Foremost among these are labor factors, community attitudes, building costs, and water. Labor factors include many interwoven threads, such as wage rates, work loads, worker attitudes, union attitudes, and competition for labor by other industries.

DAN STANISLAWSKI—*Agricultural Terraces in Portugal*

Agricultural terraces are notable in three areas of Portugal. Probably the most famous are those on the "warm" schists of the eastern half of the Douro Valley, where the grapes designed for the production of port wine are grown on elaborate terraces of unmortared stone.

Older than these, however, and more important to the Portuguese people, are the numerous areas of terraces belonging to small landowners of the northwestern province of Minho. These, virtually all on granites, are immemorially old and seemingly give the answer which Minho has evolved to the ancient problem of a numerous population pressing against the capacity of the land.

A third area, perhaps settled by men from Minho who recognized a rock similar to that of the home province, is that of Monchique, a syenitic dike protruding through the matrix of sedimentary schists of Algarve, the southernmost province of Portugal. Here the terraces, supplied with water from the precipitation caught on the relatively high slopes above them, are far more productive than the surrounding areas of schist.

Douro terraces are no longer being built in great number, because of the crisis in the port wine industry. However, terraces are still being constructed both in Minho and on the slopes of Monchique in spite of modern costs. Exploitation with irrigation has demonstrated their economic feasibility.

PETER M. STERN—*The Impact of Bauxite Operations on Jamaica, B. W. I.*

Almost overnight Jamaica has emerged as the key supplier of raw material for the mushrooming aluminum industry of North America. Its bauxite reserves,

their existence unsuspected until 1942, are the world's largest. Mining began in 1952 and within two years the rate of recovery had attained that of the much older operations in British Guiana and Surinam. Two United States primary aluminum producers and the single Canadian company in this field have made a heavy investment in land (over 3 percent of the area of Jamaica), mining and transportation equipment, processing and port facilities. In 1954, bauxite shipments were valued at 20 percent of Jamaica's exports.

How will this massive exploitation of a non-renewable strategic resource by foreign private capital affect Jamaica's program of economic development? This paper examines the influence of bauxite operations on employment, on government revenues, and on changes in land use; it evaluates the companies' agricultural activities on land not yet mined as well as on the stripped areas; and it contrasts the activities of the Canadian organization which processes the ore into alumina on the island (thus boosting auxiliary industries and freight loadings on the government railway) with those of the United States companies which, because of a differential tariff, ship the semi-dried ore to Gulf Coast alumina plants.

This is a case study of the effect of America's appetite for industrial raw materials upon a small underdeveloped community with a favorable investment climate. Because we need its bauxite we can no longer ignore its economic plight.

RAYFRED L. STEVENS—*The Mexico City Picnic Area: A Study in Recreational Geography*

Extreme altitudinal variations combine with other geographic factors in the area surrounding Mexico City to give its three million inhabitants a year-round choice of climate, landscape, and other natural recreational resources within commuting distance for a picnic (*día de campo*) or other similar one-day outing. Few other metropolitan areas can offer such a variety to so many people within the radius of a three-hour drive.

Climate largely explains the Sunday exodus of thousands from the cold site of Mexico City to the lower, warmer, and even less cloudy Cuernavaca Valley. *Picturesque landscapes,* notably those with imposing geological formations or luxurious vegetation, *hydrographic features,* especially lakes, streams, and the thermal springs of many temperatures where bathing facilities are available, *archaeological and historical sites,* and towns that still preserve an indigenous or colonial charm —all are used as picnic sites.

Good use is made of these recreational resources by Mexico City dwellers. The Mexican picnicker's particular habits, such as buying lunch materials near the picnic site, make him a considerable asset to the hundreds of catering villagers whose chief source of cash income is the sale of typical foodstuffs and handicrafts (including fake archaeological relics) on Sundays and holidays.

Thus picnicking affords a richer life for village- and city-dweller alike. With more and better roads being built in the area, it is safe to predict where new picnic sites can flourish, since the geographic aspects of the prospective customers' taste are well established and likely to remain unchanged for a long time.

ARTHUR N. STRAHLER—*Basic Principles of Quantitative Geomorphology*

Basic research in geomorphology of erosional landforms has been directed toward development of new quantitative methods of analysis. First, the complex geometry of landform assemblages has been broken down into component parts through dimensional analysis. Scale of landform units is given by form properties having the fundamental dimension of length, such as stream length, drainage basin area, and relief. Shapes of landforms are expressed in such dimensionless ratios as slope of ground surface, stream channel gradient, relief ratio, basin circularity, and hypsometric integral. A similar dimensional analysis can be applied to landforms of any origin or classification to yield purely empirical, quantitative statements of terrain for a wide variety of geographical, military, and engineering applications.

Second, the methods of mathematical statistics have been applied to sampling, analysis, and testing of numerical data specified by dimensional analysis. Statistical parameters, such as mean and variance, not only provide standards for description of landscapes, but also make possible the rigorous testing of hypotheses as to similarities between regions.

Third, an attempt has been made through rational processes to set up mathematical models linking landform geometry to dynamic causative factors. For example, a general equation for the longitudinal profile of a stream is deduced from considerations of controlling geologic factors; or size of drainage basin is related to factors controlling intensity of erosion. Through this threefold basic research program, the prospect that quantitative geomorphology will contribute to other fields of geography and geology, both theoretical and applied, is greatly improved.

RICHARD S. THOMAN—*A Foreign-Trade Zone (Free Port) on the Great Lakes–St. Lawrence Seaway?*

Now that the St. Lawrence Seaway is materializing, questions are arising concerning the feasibility of a foreign-trade zone, or free port, along the route. Suggested sites include Cleveland, Detroit, and Chicago in the United States, and Montreal, Quebec, and a district adjacent to the Welland Canal in Canada.

Since a free port is designed primarily to stimulate re-export commerce, its introduction into the Great Lakes–St. Lawrence Seaway involves consideration of its record elsewhere. Seven units have been recently established in the United States. Of these, three have closed, two are functioning at a financial loss, and two at only a small profit. Although the device is still popular in the major north European seaports of Hamburg and Bremen, it has found only casual acceptance in the smaller ports of prewar Germany and in Scandinavia. Available data relevant to the past quarter century indicate that, even in the Hansa ports, (1) reexports usually comprised less than twenty percent (by value) of all foreign merchandise warehoused in the free ports, and (2) a few commodities accounted for most such commerce.

In view of the record of the free port in both northern Europe and the United

States, the device should not be permitted along the Great Lakes–St. Lawrence Seaway until (1) traffic there has stabilized, (2) such traffic has been thoroughly appraised, and (3) additional studies have revealed the total effectiveness of the free port, as compared with alternative systems, in facilitating re-export and import commerce.

BENJAMIN E. THOMAS—*The American Concept of Deserts and Oases*

The desert in America has shrunk from the entire western region to an arid core in the Southwest, but Americans disagree on general terms for the dry lands that they have excluded from "desert," leading to confusion in both America and Europe. Many geographers use "steppe" for the semiarid Great Plains; climate, soils, landforms, vegetation, and land use (grazing and wheat farming) fit the concept. Likewise, there is often agreement that areas like Death Valley are "deserts" in all important aspects. But the Wyoming Basin, the Snake River Plain, etc., are only semiarid with a partly desertic nature, considering all elements from climate through land use and settlements. Perhaps "semi-desert" is a suitable term for such areas. The use of "steppe," "semi-desert," "desert," and "tanezrouft" (extreme desert not found in the United States) provides four categories as shown on the map *Dry Lands of the World*. It is hoped that the classification and map may improve regional description, replace the 10-inch precipitation theory, facilitate comparisons among continents, and make American terms understandable to European geographers.

While restricting the deserts, some American geographers have extended "oasis" to apply to irrigation agriculture in semiarid, mediterranean, and savanna lands. It seems more appropriate, however, to restrict oasis to the deserts and use terms like "irrigated areas" for other regions. This would preserve the original meaning of "oasis" and help clarify our concepts and terminology.

WILLIAM L. THOMAS, JR.—*Notes on the Concept of Culture*

The culture concept is an under-employed tool in modern geography. James, in his Presidential address and in *American Geography*, states that the significance to man of the physical-biotic quality of the land is a function "of the attitudes, objectives, and technical abilities" of people. These are cultural characteristics.

Culture is the distillate of total human experience, which not only distinguishes mankind and all its members from other living forms, but, indeed, sets man apart as a unique evolutionary product. Man, as "culture-bearer," is the first species with the ability consciously and deliberately to alter the course of his own evolution.

Through culture, man has become the ecologic dominant on the earth. Through individual cultures (the different technico-mental systems developed through time by the many fragments of mankind), men have been provided the value systems and knowledge of tools and techniques by which they have selectively interpreted their physical-biological habitats and, in acting upon them for their own ends, have changed the face of the earth.

This paper outlines some characteristics of culture, distinguishes between culture (holistic) and cultures (partitive), and poses such questions for geographers as: Is a region to be studied from the viewpoint of those who inhabit it? If so, are geographers to undertake study of man's attitudes toward the land? Are geographers, in their study of how resources are interpreted and used, to formulate explicit statements concerning the value system of a people, and, hence, to contribute more fully to those questions that concern the social sciences and the humanities?

JOHN H. THOMPSON—*Urban Agriculture in Southern Japan*

A distinctive type of agriculture within the general framework of paddy rice cultivation has developed around the large cities of Japan. It is here referred to as urban agriculture.

The purpose of this paper is to present a case study representative of urban agriculture in southern Japan. The principal focus is on seasonal variation in crops, and on patterns reflected in farm and crop maps.

A small area on the Osaka Plain was chosen for detailed examination. It contains thirty-five acres and lies half way between Osaka and Kobe. Crops in this area were mapped in March, April, and August 1954 and January 1955. Farm boundaries and farm houses were located.

Individual paddies averaged about 0.2 of an acre in size. Only 2 percent of them contained just one crop during the year; 21 percent contained two different crops; 56 percent three crops; and 21 percent four crops. These figures do not take into account two plantings of the same crop in the same paddy. Some fields produced six crops during the year. Owner operated, non-contiguous units predominated. Most of the thirty-five farmers working the land lived in the immediate vicinity.

Crop maps for January, March, and April all show the importance of such winter crops as cereals, greens, cabbage, and strawberries. These three maps, however, differ considerably. On the August crop map over eighty percent of the land is in rice. In this case only tomatoes and eggplant competed successfully with rice.

JOHN L. THOMPSON—*A Case Study of Interregional Labor Migration*

In the opinion of industrial administrators of the Miami Valley in southwestern Ohio, two major location factors are significant to success in manufacturing. These are: (1) central location with respect to market and (2) excellent labor supply. Labor supply is unique with respect to its source, a depressed agriculture region in eastern Kentucky. Kentuckians compose 36 and 38 percent of the labor force of Hamilton and Middletown, Ohio, respectively. While Kentuckians are not as numerous as Ohio-born employees, their influence as a source of labor for expansion and attraction of industry is disproportional to their numbers. Kentuckians are a source of cheap semi-skilled and unskilled labor; this gives the Valley its labor advantage. They come from a hilly area where agriculture and mining is on a subsistence level.

Remoteness and a low standard of living have created clannish attitudes which are evident in migration; Hamilton and Middletown (thirteen miles apart) have different Kentucky counties as labor sources. This difference in source is also evident within individual plants of the same company and between departments in the same plant.

The newly arrived Kentucky-born migrant has created industrial problems, e.g., absenteeism. He also creates social problems in his community. Clannishness causes him to settle in congested areas having poor living conditions. As a result considerable social work must be done. Much of the burden of this work has been undertaken by the industrial plants.

C. WARREN THORNTHWAITE—*The Climatological Atlas Project of the World Meteorological Organization*

A proposal for a world climatological atlas originating in the Commission for Climatology of WMO was approved by the Second Congress of the World Meteorological Organization in May 1955, and a working group was established to draw up plans and prepare a prospectus. According to the report submitted to the Executive Committee the atlas is to consist of two parts: (1) physical climatology and (2) dynamical climatology. Only the physical section has yet been organized. It will consist of maps concerned with the heat balance and the water balance of the earth. Several elements never before mapped are included. In the heat balance series, maps will show albedo, soil thermal conductivity, and convective heat loss. The water balance series will contain maps of potential evapotranspiration, water surplus, water deficit, actual evapotranspiration, and soil moisture. New interpolation methods are needed for these new elements.

MAZIE O. TYSON—*The Danish-American Virgin Islands: The Changing Economy*

The Danish-American Virgin Islands are located near the eastern extremity of the Lesser Antilles crescent. The two larger islands of the northern group, St. Thomas and St. John, are of igneous origin. Small areas of limestone and coral occur along the coast. Larger islands and smaller cays have large areas of bare rock surface. Slopes of more than 60 percent occur in many places. On the slopes, soil is very thin or absent. Vegetation is scrub or cactus, in response to soil character and almost total absence of ground water. South of St. Thomas, across about thirty-two miles of open water and a deep of 2400 fathoms, is St. Croix, the largest island of the group.

The climate is "Trade Wind Tropical." Mean annual temperature range is less than eight degrees. Annual range may be from a winter minimum of 65° F. to a summer maximum of 97° F. Average rainfall is between 45 and 48 inches, with great variation from year to year. Fresh winds from the sea provide a pleasant atmosphere at all times.

The islands have a total area of 132 square miles and a population (1950) of 26,665. They have been occupied by Arawak and Carib Indians, Danes, Dutch,

English, and French. Most recently they became by purchase a possession of the United States. Evidences of past glory in agriculture and commerce remain, but new emphasis is on the strategic location as a military base and as a tropical playground for tourists.

STEPHEN S. VISHER—*Changing Significance of Environmental Influences at Bloomington, Indiana*

Several environmental influences have affected Bloomington, Indiana, distinctly differently at different times. Among these are location in the state; rolling topography; and position on a drainage divide underlain by an exceptional limestone and in a wooded, unglaciated area.

Bloomington was established in 1815 adjacent to tl site of the state school (now Indiana University) in the support of which a township of public land had been donated. It was near the center of Indiana's population then, but in a sizable unsettled area still politically unorganized. Promptly a county was created with Bloomington as its county seat.

Copious springs, fed by sinkholes in the limestone, an early prized asset, became liabilities as pollution followed settlement. The fertility of the pioneer soil was soon badly reduced by erosion. Bloomington soon came to be far from the center of the state's population. As the University expanded, the rolling topography became an asset through increasing attractiveness for residential development. That Bloomington is in a densely wooded area first was a liability, but it became, for a few decades, an asset for it supported a furniture factory. Bloomington's location on a drainage divide was helpful; an early road and the city's second railway follow the divide. Recently, position on a divide has increased problems of water supply and sewage disposal. The limestone was unimportant for several decades but then became significant as the base of an important stone industry. In recent decades, the presence of limestone has greatly complicated domestic water supply problems.

WILLIAM H. WALLACE—*Distribution of Passenger Traffic on New Zealand Railways*

Nearly three-quarters of all passengers carried by the New Zealand Railways travel on the North Island lines.

Passenger traffic is heaviest in the five large urban areas where suburban trains are operated. Within these suburban zones passenger traffic is greatest on the lines with the most frequent and rapid train service and where the population is concentrated near railway stations. Secondary maxima in passenger traffic commonly occur at the "outermost" depots reached by suburban trains because the attractiveness of suburban rail traffic increases with the length of the journey. Two coal field branch lines, which provide a commutation service linking mines and dormitory towns, also have conspicuously heavy passenger traffic.

Fast and frequent runs by diesel railcars provide a service so attractive that

traffic on the lines over which they operate is large relative to the number of people in the tributary areas of these railways.

The characteristics of the "on-line" population, in terms of income levels, mobility, and attitudes toward travel, are other factors which are significant to the localization of passenger traffic. In New Zealand the presence of two groups, Maoris and military personnel, tends to stimulate passenger activity at nearby rail depots.

Among the factors which determine the pattern of railway passenger traffic in New Zealand, the following are of greatest importance: (1) the general distribution of population, and locally, the situation of people relative to railway stations; (2) the "quality" of railway service; and (3) the "characteristics" of the population.

HENRY J. WARMAN—*Significant Tempero-Spatial Elements of Human and Cultural Geography*

After a brief introduction discussing elements of cultural geography, the paper continues with a treatment of cultural developments of great significance. Such developments as the family, printing, metallurgy, pottery and ceramics are weighed in the light of their importance and areal distribution.

The significance of these developments through time to cultural elements in modern society is traced. The need for tempero-spatial as well as spatio-temperal approaches to the field of human and cultural geography is stressed.

FREDERICK L. WERNSTEDT—*Phillipine Interisland Shipping and Trade*

In an archipelagic nation like the Republic of the Philippines an effective transport must be provided over water routes. Present-day Philippine interisland shipping and trade patterns evolved principally under the United States administration with a policy of relatively unrestrained Philippine foreign trade. Hundreds of individual regions producing exclusively for overseas markets came into existence. Internal movements of the export commodities to the larger export ports and the return flow, of foodstuffs principally, provided the stimuli for development of an interisland shipping fleet.

Today over six thousand motor and sail vessels, aggregating more than 400,000 gross tons, serve to funnel the export products of sugar, copra and Manila hemp into one of the eleven customs-staffed ports. Only bulkier commodities, like logs, lumber, and mineral ores, move directly from production sites. Foreign-origin manufactures and domestically produced foods, such as corn, rice, fish, and livestock, provide return cargoes.

Lightly settled Mindanao Island furnishes the bulk of Manila's hemp export, the majority of Philippine timber export, and surplus foodstuffs for internal distribution. The thickly populated Visayan Islands supply sugar to Manila and copra to Cebu, and require supplements of food. Luzon, focusing on the port of Manila, produces hemp, sugar, lumber, and copra for export and requires modest food supplements.

Manila functions principally as a foreign port and hence is a recipient of export interisland commerce. Cebu, Iloilo, and Zamboanga serve as secondary export ports and primary interisland trade foci. Other Philippine ports provide origins or termini for interisland commerce.

WILLIAM A. WITHINGTON—*Suburban Migration: A Case Study of Winchester, Massachusetts, 1930 to 1950*

Migration has been a major factor in the rapid suburban development of the United States. This is illustrated in Winchester, Massachusetts, a predominantly residential suburb of 15,000 people eight miles northwest of Boston. The study of Winchester between 1930 and 1950 indicates that: Most suburban migrants move short distances. Long-distance migrants are increasingly important proportionately and numerically. Peripheral areas of suburbs where new dwelling construction is greatest are most active as areas of in- and out-migration. Central, older residential areas of suburbs have the greatest amount of intra-migration. The number of migrants into, out of, or within a suburb in a twenty-year period may equal its total population. A stable group of residents do not migrate.

Two-thirds of the in-migrants moved short distances, coming from within the Standard Metropolitan Area of Boston. Seven percent of the in-migrants came from the remainder of Massachusetts; an equal percentage, from the rest of New England; almost sixteen percent from the rest of the nation; and two percent from foreign areas. Peripheral areas of the suburb, where most of the new homes were built, were destinations of most in-migrants. Out-migrants were most numerous from these same areas. The majority of intra-migrants moved between homes in older, centrally located, residential areas. Only a few of the intra-migrants moved directly into new homes built between 1930 and 1950.

LAURENCE GRAMBOW WOLF—*Mineral Production and Contemporary Geopolitical Patterns*

This paper describes the present distribution of the production of fourteen common metallic minerals and mineral fuels in terms of the present arrangement of nations and colonies into regions of varying cohesiveness in response to the present polarity of power. Mineral consumption and reserves are not encompassed. Three-year averages are used to overcome possible atypical conditions of any one year. The averaged years are 1950–51–52 to indicate postwar conditions and, where possible, 1936–37–38 and 1922–23–24 to show regional trends. Included are coal, petroleum, iron, chromite, manganese, molybdenum, wolfram, bauxite, copper, lead, zinc, nickel, tin, and antimony.

The geopolitical pattern consists of the Soviet Realm (East Europe, USSR, Communist Orient) surrounded by the "Zone of Containment" (Anglo-America plus the Rimlands of West Europe and Mediterranean, Middle East, South and Southeast Asia, noncommunist Far East), and backed by reserve regions of Middle

America, South America, Transsaharan Africa, and Oceania. Data are presented in tables and diagrams.

The pre-eminence of Anglo-America is marred by lack of ferro-alloys and tin. West Europe-Mediterranean and USSR rival for second place, each with serious deficiencies. Transsaharan Africa, South and Middle America are more productive than remaining regions. Were the Soviets to gain West Europe-Mediterranean, they would surpass Anglo-America in eight of the minerals. Were they to gain other rimland regions, their per capita mineral production would be greatly lowered, with little production added. The potential Arab Realm, zones of nationalist unrest, and underdeveloped areas possess slim mineral production bases for swift industrialization.

WILLIAM C. WONDERS—*Repercussions of War and Oil on Edmonton, Alberta*

During the early years of World War II Edmonton figured in military activity not only as a center for enlistment, but also in the British Commonwealth Air Training Plan and in the development by the federal government of airport facilities along the Northwest Staging Route. The latter became of vital importance as an essential link with Alaska when the United States entered the War. Construction of the Alaska Highway and the associated Canol Project focused attention on Edmonton as the main base of operations. The resultant influx of American service personnel raised the population of the city to the point of straining local housing and service facilities.

Postwar readjustment was scarcely under way before the discovery of oil in February 1947 at Leduc, 20 miles south of the city, touched off a new era for Edmonton. Successive discoveries established the city as the center of Canada's booming oil production. The city's economic base was greatly widened with the introduction of oil refineries, petro-chemical industries, and others using natural gas or by-products.

Population soared from 90,419 in 1939 to 115,745 in 1945, to 209,353 (232,000 in Greater Edmonton) in 1955, and this soaring increase has led the city to claim the title of "fastest growing on the continent." At the same time, municipal problems have increased, particularly in financing the greatly increased service facilities needed, and have caused the provincial government to create a royal commission to study the problems of development and administration of the Edmonton and Calgary metropolitan areas.

WALTER F. WOOD—*Increasing the Value of Small-Scale Maps for Landform Study by the Use of Statistical Inference*

An investigation of the rate at which slope detail is lost with an increase in map scale reveals that the rate is more or less fixed. This allows statistical inference to be used for supplementing terrain information gained from medium- and small-

scale maps, and overcomes in part the lack of good topographic map coverage at small scale.

The methods for accomplishing this end are demonstrated with regard to contour crossings laid out on topographic maps of Germany. A study of fifty-three random samples lying near longitude 10 degrees East between the Baltic Sea and the Austrian border provide the necessary data. These samples, outlined on maps of different scales, are square in shape and contain nine square kilometers each. As would be expected, fewer contours are usually encountered along identical traverses as scale decreases. This is true even when adjustments are made for larger contour intervals at the smaller scales. Correlations of contour counts, relative relief, elevation, distance from the sea, percent of land in forest, and other measures permit the construction of multiple regression equations for predicting the number of contour crossings on maps of a scale smaller than the data source. The accompanying standard errors are small enough to make the use of these equations worthwhile.

If we assume that orderliness exists among individual ingredients of the landscape in all parts of the world, these methods should have universal applicability.

WILBUR ZELINSKY—*A Method for Measuring Change in the Relative Distribution of Manufacturing Activity*

This paper presents a technique for measuring change in relative concentration of manufacturing activity among regions of a nation, applying this technique to the United States for the period 1939–47. The suggested formula differs from previous methods as follows: (1) multiple indices are used, results being expressed in terms of employees, value added by manufacture, and per worker productivity; (2) the close interrelationships between population and manufacturing change are recognized through the incorporation of population data into the formula; and (3) the unit areas are the multicounty and economically relatively homogeneous State Economic Areas. These are combined into six industrial regions, which disregard state boundaries, and several non-industrial regions.

The formula operates roughly as follows. Percentage of total population engaged as production workers and value added per capita (of total population) are computed for each SEA for the earlier year and results are multiplied by the factor of national change in these indices for projected values in the latter year. Assuming that an SEA must reach a projected value to maintain relative concentration of manufacturing activity, the difference between actual and projected change is termed relative change. Computations for both indices and per worker productivity, which represent differences between the two, show how the subject area has fared relative to the nation and other State Economic Areas, allowing for population change.

Because of the unusual character of the 1939–47 period, general conclusions concerning long-term industrial migration are deferred until completion of a study covering the entire 1899–1954 period.

WILBUR ZELINSKY—*The Effects of the St. Lawrence Seaway on the Chesapeake and Ohio Railway*

In 1954 the Chesapeake and Ohio's Industrial Research Department conducted a study to determine the economic effects of the opening of the St. Lawrence Seaway, and the following tentative predictions were made.

As regards the Seaway's general effects: (1) it will carry some 44 million tons of traffic by the late 1960's, including 17 million tons of foreign traffic, a small fraction of national totals; (2) little change will occur in present patterns of coal and petroleum movement, somewhat greater changes in general cargo traffic, and considerable diversion of ore, grain, and flour; (3) there is almost no prospect of any water transport between Lake and North Atlantic ports; and (4) the greatest ultimate effect may be the stimulation of Midwestern industrial development.

As regards the particular effects on the Chesapeake and Ohio: (1) the Railway's huge coal traffic will not be appreciably affected, nor will general merchandise traffic; (2) 17 percent of the Railway's 1953–54 foreign non-coal traffic is potentially divertible to the Seaway—only 0.5 percent of total non-coal tonnage; (3) some 100,000 to 500,000 tons of export trade annually can be developed via Lake ports; (4) in the short run, present traffic lost will be roughly balanced by new traffic to Lake ports, with the net impact on Company revenues extremely slight; but (5) eventually the Seaway's stimulus to industry may prove highly beneficial to the Chesapeake and Ohio, which serves plant sites on and near the Great Lakes.

LEONARD ZOBLER—*Using Significance Tests to Organize Economic Regions*

The problem of organizing the states of the United States into homogeneous state groups confronts many private and government agencies. A method for establishing such regions objectively is described in this paper. This method employs tests of statistical significance for regional homogeneity. The chi square test is well adapted to the study of the homogeneity of two areas.

In the organization of state regions, West Virginia is placed with the Mid-Atlantic states (New York, New Jersey, Pennsylvania) or with the South Atlantic states (Maryland, Delaware, Virginia, North Carolina, South Carolina, Georgia, Florida, Washington, D. C.). It is never placed with the East South Central states (Kentucky, Tennessee, Alabama, Mississippi). With which state group does West Virginia belong, or have a homogeneous economic structure?

The number of workers employed in the primary sector of the economy (agriculture, forestry, mining, fishing) and in manufacturing in West Virginia was compared with the number of workers in the same industries for each of the above groups of states. The results of the tests showed significant differences in the distribution of the labor force between West Virginia and the Mid-Atlantic states and the South Atlantic states. There was no significant difference between West Virginia and the East South Central states.

These results may be interpreted to mean that West Virginia should be grouped with the East South Central states because their economic structures as compared by the above method are homogeneous.

Raye R. Platt, editor. *Finland and Its Geography.* New York: Duell, Sloan, and Pearce; Boston: Little, Brown and Company, 1955; prepared by the American Geographical Society, 410 pages, 2 appendices, index, illus.

Any favorable recognition of Finland by foreigners and particularly by persons or institutions in the United States is always deeply appreciated by all Finns. The citizens of Finland had a hard struggle to gain their independence and subsequently have put forth considerable effort to earn the respect of other peoples. In this they have been almost uniquely successful.

The volume considered here, prepared by the American Geographical Society under the sponsorship of the Geographic Branch of the Office of Naval Research, has been well received by many Finns. This is to the society's credit. Inasmuch, however, as the treatise is the first in a proposed series of handbooks on various nations, it deserves perhaps closer than normal scrutiny. The editor asserts that these handbooks will be "neither scientific treatises intended only for the professional geographer nor mere compendia of facts, but basic information presented with a view to creating and sustaining reader interest."

The opinion of a single reviewer based upon his own knowledge of a particular subject and upon his reaction to the form of its presentation does not necessarily gauge the reception which a book might be given by a dozen or a hundred other readers. As a matter of fact, we have no serious adverse criticism of the accuracy of the content. It is our impression, however, that the American Geographical Society has not attained its goal. Unless a reader has a particular interest in Finland, in all probability, upon sampling the presentation, he will not acquire the urge to read on. To the reviewer much of the reading matter is dull. Of course, it is conceivable that the latter's own familiarity with the subject tends to remove the "newness" from the story which to the uninitiated might yield a sufficiently strong appeal to hold his attention from beginning to end.

Finland and Its Geography contains much non-geographic comment. Consideration of hospitals, medical controls, social structure, politics, manufactures, and other topics, without associated geographic interpretation can be excused only on the assumption that this work is not intended to be solely geographical. There is no particular objection to popularization. In fact, it ought to be undertaken now and then by those who are competent in their respective sciences. In this instance, it should be in keeping with the high scholarly level for which the Society has an outstanding reputation.

The preface acknowledges an extensive literature in the French and Swedish languages and states that "little of this material is available in the English language." We cannot avoid challenging this statement. The Finns have recognized the difficulties of their language and the unlikelihood of many non-Finns acquiring skill in reading it. Therefore, they have long published many of their most important works in German, French, Swedish, and English. In other instances they present summaries or abstracts of untranslated papers in one or more of the more widely comprehended languages.

At many places in the text, statements sounded so familiar that we checked back through some of the literature with which we were acquainted and came upon some interesting revelations. The pattern bears a striking resemblance to a volume written in German which appeared in 1919. This carries the title *Finland im Anfang des XX Jahrhunderts.* It was sponsored by the Foreign Office of Finland. Somewhat later, 1926, a book in a more popular vein, but still authoritative, came out of Finland under the title *Finland, the Country, Its People and Institutions.*

More recent than either of the volumes just cited is *Suomi, A General Handbook on the Geography of Finland* which, as noted in the Preface, appeared as volume 72 of the Fennia Series published under the auspices of the Geographical Society of Finland in 1952. It includes 620 pages, plus index, divided into 36 chapters, each written by a specialist in the particular topic under consideration. We chose a chapter at random for comparison with the book reviewed here—Chapter 29 on "Forests and Forestry." This corresponds with Chapter 7, "The Forest Industry," in *Finland and Its Geography.* The parallelism of the opening paragraphs is so striking we quote them both.

> *From Fennia:* "The natural conditions in Finland vary to such an extent from the southern coast up to the northernmost fjeld regions that the landscape

> attains most diverse shapes. The forest, however, maintains its position tenaciously throughout the Finnish landscape. Hardly any wide area can be found which entirely lacks the green covering provided by a forest. Neither do regions worthy of mention exist where the inhabitants would suffer from a shortage of wood."
>
> *From Finland and Its Geography:* "Natural conditions in most parts of Finland are highly favorable for both forest growth and the timbering industry. There is hardly a section where forest cover is lacking, and there are none worthy of mention where the inhabitants would suffer from a shortage of wood for fuel and lumber."

Comparison of other portions of the respective treatments of the subject tempts one to state that the book under review actually could serve as a "paraphrase" of the Fennia volume or of a combination of the three works we have just noted, even though we are confident this was not intended. It does, however, point up the fact that there has been no dearth of material concerning Finland and its geography for those interested in the subject. About the only significant difference between *Finland and Its Geography* and its predecessors published abroad occurs in the quality of the English employed. Perhaps its issuance from an American press makes the story of Finland more readily available than otherwise, although its high selling price certainly will discourage purchase by many individuals.

Why the sequence of topics constituting the respective chapters was chosen is not explained. The cooperative movement which ramifies just about every walk of life and the membership of the cooperative societies which includes representation from practically every family in Finland are much more intimately associated with the agricultural life of the country than with any other phase. So it is that we wonder why the subject is treated in Chapter 10, five chapters after Agriculture. Chapter 13, carrying the title "Cartography," seems wholly gratuitous. Anyone familiar with cartographic productions in Finland will concur most heartily with the Society when it commends Finnish skill and the beauty of the product. But why inject this subject here? Is it a kind of apology for the non-geographic discussions which have gone before?

The text is well illuminated with photographs, maps, charts, and diagrams. Statistical data are abundant. The general mechanical make-up of the book is attractive.

Bibliographical references reveal, in a sense, a cross-section of Finnish activity in the field of geography. Although essentially every phase of geography is pursued in Finland there can be no doubt that the physical receives most attention. Worthy of comment is the fact that a country so small in population should yield so many excellent geographers. Not all of them can be listed here, but certainly a few should be noted.

Dr. J. G. Granö, one of the pioneers in the recent period, has made important contributions to the regional aspect, both physical and humanistic. He also has shared in the geomorphological realm and has had a profound influence upon many of the younger geographers. Granö's part in the preparation of the noted *Atlas of Finland* will be long remembered both for originality in concepts and beauty in cartographic presentation.

Leo Aario, Väinö Auer, and young men like K. Kekoni have placed their stamp upon the fields of urban and regional geography. Yrjo Ilvessalo has done outstanding work in forestry. In the fields of meteorology and climatology V. V. Korhonen and J. Keranen are distinguished. Martti Kovero, economist and statistician, and Director of the Central Statistical Office, is recognized by geographers for the exceptional service he has rendered them not only in the collection of data but in many of his interpretations. The yield of his office has been second to none.

We are tempted to assign geographical reasons for the virility of the science in Finland. The country is not only small in area, but under the limitations of its climate and its surface conditions, a high level of culture could have been achieved only by sound scientific leadership. Intelligent study of natural conditions was essential to enable the population to make adjustments appropriate to the "mastering" of many natural obstacles to life. These circumstances have provided a fertile field for applied as well as theoretical geography.

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